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**CAN THE COSTS OF THE
WORLD HEALTH ORGANIZATION
ANTENATAL CARE PROGRAMME
BE PREDICTED IN
DEVELOPING COUNTRIES?**

Guy Hutton

Thesis for the submission of a PhD

London School of Hygiene and Tropical Medicine

Abstract

The aims of this thesis are to identify and test alternative methods for analysing and predicting health care costs, to construct a framework for guiding analysts in making better cost predictions, and to identify future areas of research in this area. The thesis uses costs collected from a multi-country trial measuring the cost-effectiveness of an evidence-based programme of antenatal care. Detailed costing studies of maternity services (antenatal care, childbirth and postpartum care) were done in two trial countries (Cuba and Thailand), and also a nontrial country, South Africa.

Costs are broken down and reviewed by cost components: prices, resource use, and health service use. The review initially considers the application of economic theory to public health care institutions, to identify factors likely to cause cost variation between setting. Then the review seeks empirical evidence proving or disproving the existence of these factors from the health care literature, as well as a review of the methods for analysing health care costs.

The empirical analysis first compares health service use, unit costs and cost per pregnancy between settings (between: women with different case-mix, health facilities, trial arms and study countries) and examines the causes of variation, before testing alternative cost prediction methods. Variations in unit cost are found to be due to several factors, including different levels of resource productivity, occupancy levels, staffing patterns, prices and exchange rates (between country), input mix and health facility size. Also, uncertainty and measurement error are considered likely to cause some variation in unit costs. Variations in health service use are due to case-mix, clinical practice, and accessibility differences. Again, not all variation is explained. Finally, a range of different cost predictions methods are tested, and their results compared with observed costs in each country. The most accurate cost prediction method is to build costs based on expected changes in resource use, health service use and morbidity rates (called the incremental cost impact approach). The direct and adjusted cross-country transfer methods (transferring costs between countries), although accurate on occasions, are less reliable. Cost predictions using predictors from a regression analysis are highly unreliable for cross-country predictions.

Methodological issues and policy implications in relation to cost prediction and generalisability are discussed, including the choice of cost prediction approach, the valuation methods (opportunity cost and currency conversion methods for cross-country predictions), the measures used for comparing the performance of cost prediction methods, and the limitations of cost analyses to understand costs. It was concluded that caution is needed in predicting costs both within study countries due to cost variability, and in lower-resourced settings where unit costs and health service use are lower. Further cost analyses and testing of cost prediction methods are needed in other areas of health care to compare with the results from this thesis, and build a fuller picture of cost behaviour as well as strengths and weaknesses of alternative cost prediction methods.

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Acronyms

AC	Average cost
ACPP	Average cost per pregnancy
ALOS	Average length of stay
ANC	Antenatal care
BLUE	Best-linear unbiased estimator
COV	Coefficient of variation
CPP	Cost per pregnancy
CS	Caesarean section
DEA	Data envelopment analysis
DRG	Diagnostic-related group
EOS	Economies of scale
FDC	Family Doctor Clinic (Cuba)
FTE	Full-time equivalent (staff member)
GDP	Gross domestic product
HDP	Hypertensive disorders of pregnancy
HMO	Health Maintenance Organization
HSU	Health service use
IPA	Inpatient admission
IPD	Inpatient day
K	Capital
L	Labour
MC	Marginal cost
MCPP	Marginal cost per pregnancy
MFC	Minimum feasible cost
MRA	Multiple regression analysis
MRTS	Marginal rate of technical substitution
NN	Neonatal
OLS	Ordinary least squares (regression)
PP	Postpartum
PPF	Production possibility frontier
PPP	Purchasing power parity
RCT	Randomised controlled trial
RPR	Rapid Plasma Reagent (syphilis test)
SD	Standard deviation
SE	Standard error
STD	Sexually transmitted disease
TE	Technical efficiency (score in DEA)
UTI	Urinary tract infection
VD	Vaginal delivery
W.H.O.	World Health Organization

Glossary of terms

Accurate	This term is used in the context of cost prediction, where a cost prediction is judged 'accurate' if the 95% confidence interval of a predicted cost falls within the 95% confidence interval of observed cost.
Adjusted cost transfer	A cost prediction method that involves prediction of costs in one setting based on the costs in another setting, but where adjustments are made using local data from the setting where costs are being predicted (if in different countries, adjusted transfer is in a common currency)
Allocative efficiency	Maximisation of outcome (health) with minimum cost.
Average cost	The full cost of a single health service or unit of production, including fixed resources and overheads.
Cost estimation	Costs are calculated using primary data sets (also termed 'observed' cost).
Cost prediction	Costs are calculated using secondary data sets, or a mixture of primary and secondary data sets.
Direct cost transfer	A cost prediction method that involves prediction of costs in one setting based on the costs in another setting (if in different countries, transfer is in a common currency)
Economic significance	Economic significance in this thesis is defined to occur when cost differences amount to more than the cost of a single antenatal care visit.
Economic efficiency	Maximisation of outputs (health services) with minimum cost.
Economies of scale	A proportionate increase in all inputs leads to more than a proportional increase in outputs, thus leading to lower average costs.
Economies of scope	An increase in the number of health services offered reduces average costs.
Efficiency	See 'Technical efficiency', 'Economic efficiency' and 'Allocative efficiency'
Financial cost	The price paid by a purchaser of health care resources.
Generalisability	The extent to which data can be used from one setting in another setting.
Health facility	A generic term used to denote any complete physical health care structure, such as a hospital, health centre, or stand-alone clinic
Health provider	The member(s) of staff directly involved in health care activities (e.g. nurse, general practitioner, obstetrician)
Health service use	The use of specified types of health service, such as inpatient days or outpatient visits

Incremental cost impact	A cost prediction method that identifies the cost impact of an alternative form of care over and above or below the baseline care.
Marginal cost	The additional cost of a single health service or unit of production (sometimes approximated by variable cost).
Opportunity cost	The value of a resource in its' best alternative use.
Over prediction	Predicted costs are more than observed costs
Returns to the variable factor	An increase in health service utilisation in the short-run leads to a lower average cost, as fixed costs are spread over a larger number of patients.
Significance	See 'Economic significance' and 'Statistical significance'.
Statistical significance	A statistically significant difference between two costs occurs when the 95% confidence intervals of the two costs being compared do not overlap.
Technical efficiency	Maximisation of outputs (health services) with given inputs.
Technical efficiency score	The efficiency score obtained from data envelopment analysis, where providers are compared in terms of chosen inputs and outputs.
Under prediction	Predicted costs are less than observed costs.
Unit cost	The cost of a single health service. See 'Average cost' and 'Marginal cost'.

1 INTRODUCTION

1.1 Background

The motivation for this thesis arises from a growing concern expressed in the health economic literature with the way in which costs are being generalised¹ between health care settings or estimated on the basis of inadequate data (Drummond et al 1992, Jefferson et al 1996, Buxton et al 1997, O'Brien 1997, Bryan and Brown 1998, Walker and Fox-Rushby 1998, Spath et al 1999, Coast et al 2000). The concern is that, while the principle of generalising cost data between settings is not wrong per se, analysts trying to reflect costs in their own setting often do not pay adequate attention to cross-setting differences that may cause costs to vary. Also, cost calculations may not be described or costs are not presented in disaggregated form to allow assessment of generalisability to other settings.

In the last 10-15 years, significant progress has been made in the economic evaluation of health care programmes through the establishment of an economic evaluation framework (Drummond et al 1987) and costing guidelines². However, these guidelines focus mainly on the estimation of costs and cost-effectiveness using primary research, with only limited guidance on how data can be extracted from secondary sources, such as through meta-analyses, modelling or extrapolation. Therefore, there is a gap in these guidelines on how cost-effectiveness data can be predicted or generalised from secondary sources to the settings where cost-effectiveness is needed. While some studies may identify important differences between secondary and primary settings, and make adjustments based on those observations (e.g. Menzin et al 1996), this thesis argues that at present a framework has not been constructed to deal with this adequately.

This thesis aims to contribute to filling these knowledge gaps, and it is a part of the growing recognition of the importance of this area. For example, a recent Health Technology Assessment grant in the UK was awarded to examine issues of

¹ A generalisation in this thesis means 'the application of the results of a given setting to other populations or subpopulations' (Willke et al 1998).

² For example, in developed countries several costing guidelines are widely quoted in costing studies, such as in Drummond et al (1997), Luce et al (1996), Baladi (1996). For developing countries specifically, other costing guidelines are available, such as WHO (1979) for immunisation services, Philips et al (1993)

generalisability. This project aims to improve how researchers tackle issues of generalisability at study design stage, as well as in reporting of results. Also, The Department of Evidence for Health Policy at W.H.O. is currently making global cost-effectiveness estimates for around 100 health interventions, using a costing spreadsheet to estimate what inputs are required to provide these interventions. Another initiative, The Global Forum for Health Research (based at W.H.O.) is examining whether standardised costing and cost-effectiveness guidelines can be made for predicting cost-effectiveness of a set of health interventions, using available data sources at local and international level (GFHR 1999). Finally, The CHEC project (Consensus on Health Economics Criteria list) is an international collaborative effort, aiming to develop criteria to assess the quality of economic evaluations in systematic reviews, and contains aspects of generalisability. Therefore the theme of this thesis is timely given these initiatives, and the current need for a greater understanding of what factors affect cost generalisability.

The rest of this chapter justifies further the theme of this thesis. First, the importance of costing in planning health interventions is described, and different aspects of cost are defined. Second, the importance of making cost predictions in health services research is explained, and concerns are raised concerning some of the current approaches to cost prediction. Therefore, potential ways of advancing the field are outlined. Third, the thesis aim, objectives and structure are outlined.

1.2 Cost information in decision making

1.2.1 Why are costs important?

The achievement of efficiency and equity are two fundamental goals for the allocation of resources within public health systems. Resources are severely limited in the health sector, especially in developing countries, and policy makers must make choices between alternative health care interventions and strategies to meet health targets. Therefore the search for the most efficient and equitable health interventions and

for environmental vector control, Sawert (1996) for tuberculosis control, and Kumanayake et al (2000) for HIV/AIDS prevention strategies.

strategies using economic evaluation techniques is essential to optimise the welfare of society (Sawert 1996)³.

Cost-effectiveness analysis (CEA) is one form of economic evaluation that attempts to rationalise the decision making process, by attaching costs and health outcomes to different health care processes, and comparing these processes. It has even been claimed that it is unethical not to take costs into account when deciding which patients get treated and what treatment they receive, due to the 'sacrifice' involved in using resources for these patients instead of other (potential) patients (Philips 1987, Williams 1992).

CEAs have stringent information requirements in order to be scientifically robust, as well as have relevance in other health care contexts. As the numerator in cost-effectiveness ratios, costs are essential to the reporting of economic evaluations (Drummond et al 1997). A recent development is the increasing use of randomised controlled trials (RCT) for measuring cost-effectiveness (Adams et al 1992, Mannheim 1998). From a scientific point of view, cost measurement alongside RCTs is preferable over non-experimental studies and retrospective costing because costs and benefits of alternative programmes are measured on the same patients and under controlled conditions (Drummond and Davies 1991, Drummond 1994, Drummond 1995, Pocock 1999, Petiti 2000). Cost estimation alongside these trials therefore plays a central role in determining cost-effectiveness.

1.2.2 Types of cost

In discussing 'cost', several interpretations are possible, depending on the user of information and the study context. Box 1.1 presents a typology of cost terms used in this thesis, reflecting current concepts⁴ about cost in health economics (Donaldson 1990, Rovira 1994, Baladi 1996, Gold et al 1996, Drummond et al 1997).

³ Note that a balance is often struck between efficiency and equity objectives when considering the optimization of societal welfare, as they sometimes cannot be achieved simultaneously.

⁴ However, note that different words have been used in the literature to describe these terms in Box 1.1.

Box 1.1 Typology of cost terms used in the thesis.

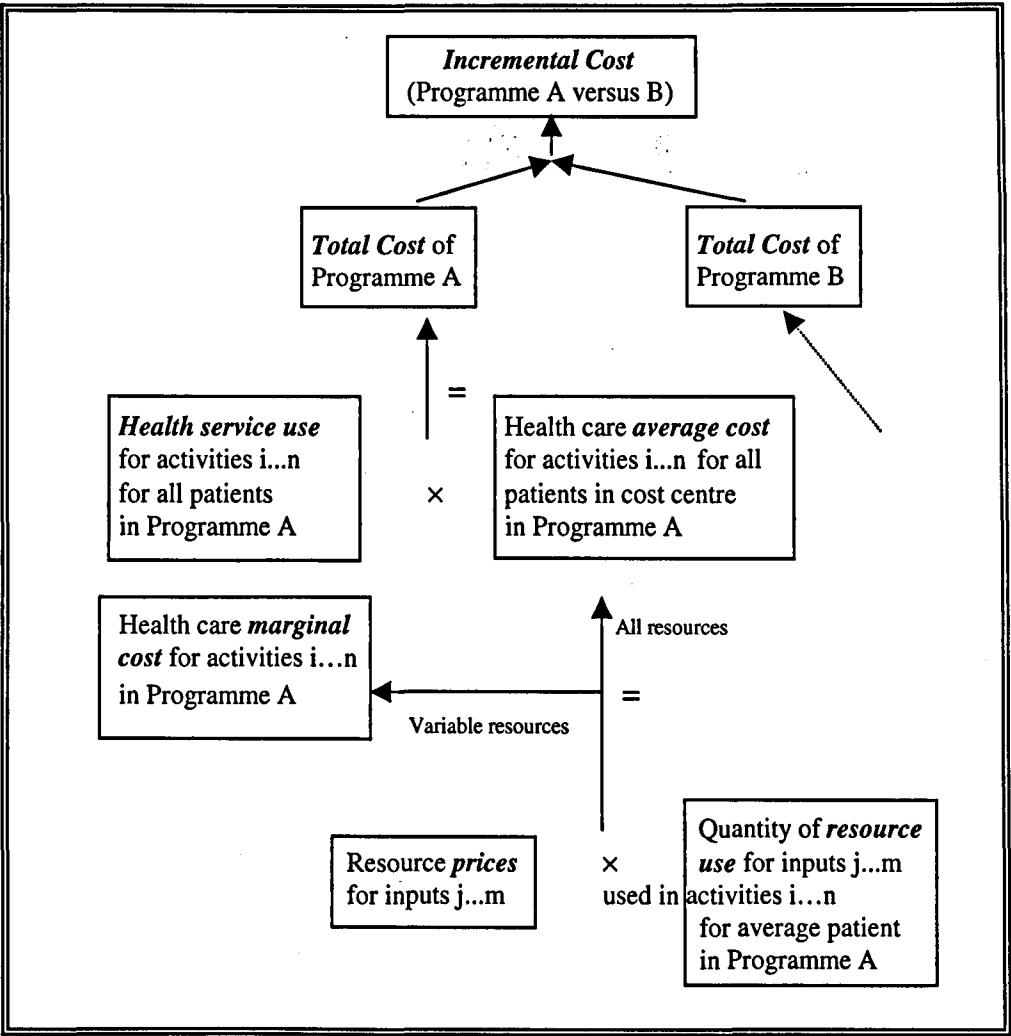
1. **PRICE.** The price of a resource. For example, the cost of a doctor hour; the cost of a single item of equipment. Two alternative prices are distinguished:
 - **ECONOMIC PRICE.** The opportunity lost due to the use of a resource in an activity.
 - **FINANCIAL PRICE.** The money paid for a resource.Therefore the costs in 4. to 7. below can be expressed in either economic or financial values.
2. **RESOURCE USE.** Quantity of resource use, in physical units. Different types of resources in the health sector used in this thesis are 'staff', 'equipment', 'materials', 'drugs', 'utilities', and 'land and buildings'. How these are defined in this thesis is described later.
3. **HEALTH SERVICE USE.** Types of health service include outpatient visits, inpatient days or admissions, operations, and laboratory tests. These can be expressed as a 'throughput' for a particular type of patient or population, and for a specified time period.
4. **UNIT COST.** The cost per health service use. This can be expressed as:
 - **AVERAGE COST.** This includes all resource inputs to the health care process (see 2.).
 - **MARGINAL COST.** This includes only resource inputs that change with one unit of production.
5. **CASE COST.** The cost for a single patient for a specified illness and/or over a specified time period. For example, the costs of a surgical case may include all outpatient visits, inpatient days, and surgical procedures associated with the surgery.
6. **TOTAL COST.** The cost of health services for a defined population, health programme or health facility, and over a given time period.
7. **INCREMENTAL COST.** The difference in the total cost of two or more competing treatments. For example, the change in costs from implementing a new procedure, such as day versus inpatient surgery.

Six types of cost are distinguished: prices, resource use, unit cost, health service use, case cost, total cost, and incremental cost. Two of these, resource use and health service use, are not in monetary form, but instead what are termed here 'natural' units. Summarising costs in non-monetary units has the advantage that components of cost can be compared across borders, without having to convert local currencies to a common currency, which may distort the comparison (Murray et al 1994). On the other hand, the advantages of summarising costs in monetary units are that costs are summarised and can be compared in a single unit or index, and the relative weights of different resources in overall cost can be understood.

Several important relationships should be noted between these costs, particularly the construction of total costs. Figure 1.2 shows that the prices and resource uses for a

single use of health service (such as an outpatient visit) are combined to calculate the unit costs (either average or marginal) of a service. This relationship suggests that to understand unit cost variation, variation in each of the resources and prices that make up unit cost should be understood.

Figure 1.1: Relationship between different types of ‘cost’.



At the next level of aggregation, unit costs are combined with health service use to estimate the overall cost, either of a programme (‘total cost’) or of a single patient (‘case cost’). This relationship suggests that to understand total or case cost variation, variation in each of the components should be understood, including all elements of health service use (inpatient, outpatient, etc.), and each of the resources and prices that make up unit cost.

At the final level of aggregation, the total or case costs of two or more forms of treatment are compared to estimate the incremental cost (at either the overall level or

patient level). Again, to understand variation in incremental cost between setting, variations in each of the components of incremental cost must be understood. As will be discussed below, this distinction between the components of different types of cost is important in making cost generalisations or predictions, as differences in each component can be compared and analysed separately, to improve the quality of the generalisation.

1.3 Cost predictions

1.3.1 What is a cost prediction?

In costing health services there exist a variety of data sources for the analyst to choose from in estimating costs (Drummond and Jefferson 1996, Nuijten 1999). For example, in building the total cost of a health care programme, the components of total cost (prices, resource use and health service use, as shown in Box 1.2) can be measured on the population in the programme or a representative sample of the population. These sources are termed 'primary' data sources, and include routine data systems, local price lists, case notes, time and motion studies, and other non-routine data collection systems set up for the purposes of research.

Alternatively, data to calculate costs may originate from other settings from where the health care intervention is being evaluated. These sources are termed 'secondary' (or non-primary) data sources, and include published data from other settings such as single clinical trials or meta-analyses of clinical trials, insurance claims databases, fee schedules, clinical guidelines of best practice, and modelled data based on assumptions or professional opinion (e.g. delphi panel technique) (Nuijten 1999). Examples of secondary sources include the use of costs from one centre in a multi-centre clinical trial to represent costs in all centres (e.g. Menzin et al 1996, Schulman et al 1996) or the use of charge data to represent actual costs (Kinosian and Eisenberg 1988)⁵. Although judgements about accuracy cannot necessarily be made based on whether costs are estimated from primary or secondary sources⁶, the use of secondary sources does

⁵ Charge data or fees could be argued to be primary sources, as they are collected from actual patients, often in the same setting as the research study. However, because these often contain a profit element or cross-subsidy, they rarely reflect actual cost, even when adjusted by an average cost-to-charge ratio (Finkler 1982). Therefore, in this thesis, they are classified as secondary sources.

⁶ For example, a good secondary source may be better than a bad primary source.

suggest greater uncertainty, or uncertainty is not known, about whether costs refer to the population for whom they are supposed to represent.

This distinction between primary and secondary data sources allows definition of the terms ‘estimated’ cost and ‘predicted’ cost, for use in this thesis. Therefore, a cost that is ‘predicted’ is defined as a cost that is based on some or all non-primary data sources; that is, data sources are from outside the setting where cost estimates are required. A cost that is estimated is defined as a cost that is based entirely on actual health care processes in the primary setting; that is, data sources are from the same setting as where cost estimates are required. Costs are therefore ‘predicted’ in any case where real health care processes are not observed in the setting where costs are required⁷.

1.3.2 The need for predicting cost

Although prospective costing using primary data sources could be seen as the ‘gold standard’ in costing, there are several circumstances in which secondary data sources may be preferable or even necessary:

- It is unfeasible to run a new clinical trial to estimate the cost-effectiveness of an intervention for every new population about which a decision must be made (Willke et al 1998, GFHR 1999).
- Cost data are not always available from routine data systems, due to poor organisation and lack of resources devoted to hospital management and accounting systems (O’Brien et al 1992, Murray et al 2000).
- The funding allocated to conducting clinical trials is often insufficient to conduct a prospective costing study using primary data. Therefore, secondary data allow quick and relatively cheap assessments of health technology before further investments in health technology assessment (Attinger and Panerai 1988).
- Costs are difficult to estimate in the early life of a new health intervention, when data are unavailable or they do not reflect costs that would pertain after wider implementation (Schulman et al 1991). A linked point is that an immediate decision may be needed, and collection of primary data may take too long.

⁷ A possible problem with this definition is that costs estimated using aggregate data from a primary source, as in the top-down costing approach, are not measuring actual health care processes, but only approximations of it. However, in this thesis these are considered primary sources.

- The types of health care for which cost estimates are required may not be provided by the health system at present, and therefore costs cannot be estimated based on current health care processes (Jefferson et al 1996).
- In collecting cost data alongside clinical trials, the costing study may disrupt health services, and even change provider and patient behaviour (Mugford et al 1998).
- The cost analysis is a national analysis, and the model sophistication and data do not exist for all costs in all settings to be estimated, and a 'representative' sample is chosen based on convenience such as what data are available (e.g. Bobadilla et al 1994, Jha 1998).

These circumstances indicate that cost predictions using generalised data or assumptions are unavoidable in many research or decision making contexts. However, while unavoidable, it does not mean that generalisations should be made without attention to the quality or accuracy of the generalisation, a point highlighted in the next section.

1.3.3 Problems arising when not using primary data sources

Despite the common use of secondary sources to collect cost data, costing guidelines say little about the way in which secondary data sources can be used and/or adapted to approximate more closely costs in the primary setting, other than by encouraging transparency and careful interpretation. Such discretion means that poor quality cost study designs may be justified on the basis that the funds and data were not available for good quality cost data (often despite huge resources being expended on the clinical component of a trial). Some authors have voiced concerns about the uses of secondary cost data. For example, Drummond et al made the following observation about the use of secondary data, in considering cross-national assessments of health technology:

"...however, the extrapolation of the results of economic evaluations from one setting to another is not a straightforward matter. A number of factors are pertinent to health technology that are known to vary from country to country...for example, differences in demography and epidemiology, differences in general and relative price levels...differences in the distribution of health care resources and their availability" (Drummond et al 1992, page 672).

In support of this statement, many other commentators have voiced doubts about transferring cost and cost-effectiveness evidence across health care settings, both within and between countries⁸. For example, in the context of mammography screening in the UK Bryan and Brown (1998) warned against the “naive and unthinking use” of published cost-effectiveness information outside the setting in which the information was generated, due to differences in the design of screening programmes. Glick (1997) also questioned whether observations about the economic impact of a medical therapy in one setting or patient population informs use about its impact in other settings or patient populations, and recommended the use of sub-group analysis. Finally, in their article on sensitivity analysis, Briggs et al (1994) recognised that cost data may not be generalisable and suggested altering parameter values to reflect the range of values in other settings to test the impact on cost or cost-effectiveness.

Many of these studies mentioned above have described or listed a number of factors that were considered to be important determinants of cost, and thus likely to be responsible for cost variation between health care settings. For example, O'Brien (1997) listed six threats to validity: different demography and epidemiology of diseases, clinical practice and conventions, incentives and regulations for health care providers, relative price levels, consumer preferences, and opportunity cost of resources. These and other factors are summarised in Table 1.1, and are grouped according to whether they affect cost through the supply side (health care provider) or demand side (patient), and whether they affect health service use or unit costs. On the patient side, the most widely quoted factors causing costs to vary were case-mix, patient costs, and patient access. On the provider side, the most widely quoted factors causing costs to vary were resource prices, financial incentives, and health care content. Empirical evidence for the effect of these factors is discussed in more detail in Chapter 4.

⁸ Commentators include Attinger and Panerai 1988, Postma et al 1993, Lee et al 1993, Briggs et al 1994, Jefferson et al 1996, O'Brien 1996, Buxton et al 1997, Mason 1997, O'Brien 1997, Glick 1997, Drummond et al 1997, Phelps 1997, Bryan and Brown 1998, Grieve 1999, Spath et al 1999, Coast et al 2000. Also of some relevance are doubts raised over the external validity of clinical (effectiveness) results to routine practice and for broader policy uses (Fisher and Carlaw 1983, Barnett et al 1987, Bailey 1994, Rothwell 1995, Lengeler and Snow 1996, Marchiola 1996, Fayers and Hand 1997, Wentzer et al 1997, Altman and Bland 1998).

Table 1.1: Factors varying between health care settings that may influence costs.

Health care provider ('supply') factors	Patient ('demand') factors
<i>Health service use, affected by:</i> <ul style="list-style-type: none"> • Financial incentives and regulations • Risk aversity of providers • Treatment guidelines • Hospital policy • Qualifications and experience of staff • Referral patterns • Provider habits and incentives for treatment • Availability of services • The perceived costs of alternative types of care 	<i>Health service use, affected by:</i> <ul style="list-style-type: none"> • Natural history and epidemiology of disease • Demography and case-mix (risk and morbidity) • Patient costs • Geographical accessibility • Risk aversity of patients • Responsiveness to care • Compliance with treatment and advice • Expectations and consumer preferences
<i>Unit costs, affected by:</i> <ul style="list-style-type: none"> • Content of health care • Absolute prices or opportunity cost • Financial incentives • Relative prices and input mix, skill mix • Provider productivity (e.g. patients seen per day per staff member) • Occupancy • Quality of care • Risk aversity of providers • Treatment guidelines 	<i>Unit costs, affected by:</i> <ul style="list-style-type: none"> • Case-mix • Expectations and consumer preferences • Patient costs

Sources: see Footnote 8.

Given the comments and findings of these studies, researchers and decision makers still face the problem that there is inadequate empirical evidence for confidently making adjustments to costs from other settings to reflect actual costs more closely in their own setting, or predicting costs using alternative techniques. This problem is compounded by the fact that different health care settings usually differ with respect to cost determinants, so guidelines can at best suggest what aspects of cost should be studied, and help analysts make appropriate choices. Therefore, the next section provides an overview of methods to improve this situation.

1.3.4 Ways of advancing the field of cost generalisability

Several ways of increasing generalisability have been identified. These relate to the conduct and presentation of published cost studies, cost analyses to understand the determinants of cost, and a comprehensive evaluation and comparison of cost prediction techniques. Each are discussed in turn.

Conduct of cost study and presentation of cost results

Three aspects of cost studies are discussed here. The first aspect involves the use of a standard approach, such as the 'reference case' (Weinstein et al 1996) so that those

generalising or comparing cost data know, for example, which costs were included or excluded, and the measurement or valuation techniques to obtain cost figures (Janowitz and Bratt 1992). While costing guidelines allow some discretion to the analyst in which data sources to use, 'consensus' articles (e.g. Drummond and Jefferson 1996, Luce et al 1996) have argued that several aspects of costing are universally important. Aspects discussed include: inclusion of relevant and important costs, a costing approach appropriate for the setting, detailed measurement of resource use, use of opportunity cost to reflect the value of resources, justification of models and assumptions, a good quality sensitivity analysis, discounting, and separate presentation of components of cost. Inappropriate methods or unjustified assumptions in costing can cause considerable uncertainty in the estimates, as well as reducing the comparability with other studies using the reference case recommendations. Another challenge to robustness that authors should be aware of in using secondary data is analyst bias, due to vested interests or prior expectations (Kassirer and Angell 1994, Evans 1995, FDA 1995).

Therefore, transparent methods are of critical importance so that readers of economic evaluations know what was done, and why. However, review studies conducted to date have found that results of economic evaluations are largely nongeneralisable, due to methods used being at variance with recommendations in economic evaluation guidelines, or lack of statement of methods (Udvarhelyi et al 1992, Heyland et al 1996, Spath et al 1999). For example, Spath et al (1999) conducted a review of economic evaluations of adjuvant therapy in women with breast cancer to assess their applicability to a decision making context in France. They first applied four initial criteria to select studies, including statement of viewpoint, comparison of at least two competing alternatives, description of therapies, and precise reporting of the effectiveness of the therapies. These criteria ruled out 17 of 26 studies identified as economic evaluations. They then applied six further 'generalisability' criteria to the remaining studies⁹. Of the nine studies evaluated, none had all the necessary characteristics to be transferred to the setting in France, and only one study was found to have sufficiently disaggregated data on costs to be considered transferable to the study setting, thus allowing adjustments to

⁹ (1) Was the alternative therapies were relevant to the local setting in France? (2) Were patient characteristics similar? (3) Were health outcomes relevant? (4) What was the cost viewpoint? (5) Were resource use quantities clearly stated? (6) Were unit prices of health care resources clearly specified?

be made. Therefore, this study highlights the problems resulting from not using or reporting appropriate economic evaluation methods.

The second aspect of cost studies involves the testing of robustness of cost estimates (Briggs et al 1994). The standard technique advocated by economic evaluation guidelines is sensitivity analysis, which shows cost results under alternative assumptions or conditions or, alternatively, the assumptions required for study conclusions to change (threshold analysis). However, the main application of sensitivity analysis so far has been static analyses (Hutton 1993, Briggs et al 1995), suggesting that the ranges presented may reflect uncertainty inadequately. The problem with static analysis is that differences between settings in production relations that determine cost are not accounted for. More recently there have been developments in stochastic and multivariate sensitivity analyses, using probabilistic, montecarlo and bootstrap methods (Doubilet et al 1985, O'Brien et al 1994, Manning et al 1996, Hunink et al 1998, Lord and Asante 1999). These approaches can, in theory, take account of interrelationships between variables and dynamic effects, if data on these are available.

The third aspect of costing study to improve generalisability is the presentation of cost data in disaggregated as well as aggregated form (Drummond and Jefferson 1996), to allow readers to assess the relevance of the cost data to his setting, and recalculate costs. This may involve presentation of prices and quantities separately (or at least describe input mix) and health service use.

Cost analysis to understand cost determinants

Costs are transferred more accurately if cost behaviour is understood in both primary and secondary settings and appropriate adjustments made (Drummond et al 1992, Menzin et al 1996). Economic theory suggests that cost behaviour depends on many interrelated factors, which are likely to vary between setting (Heathfield and Wibe 1981). The assessment of these factors requires a variety of techniques to be performed for understanding unit costs and assembling evidence of cost behaviour (Sherman 1984, Barnum and Kutzin 1993, Ehreth 1994). Such information on cost determinants has a practical use, as Jian et al (1998) points out "...to identify the most efficient way of providing immunisation services...a rough quantitative notion of the relative importance

of factors contributing to cost variation is useful". Therefore, this thesis argues that understanding costs is a critical stage before cost prediction, and therefore cost analysis techniques and results from the literature are reviewed in detail.

Compare the performance of different cost prediction techniques

In their review article on methodological issues in costing health care technologies in clinical trials, Johnston et al (1999) recommend further empirical study in methods to generalise results. None of the costing guidelines or cost analysis articles found in the literature search have described and tested comprehensively a range of cost prediction methods, nor have described means of judging what levels of inaccuracy are 'acceptable' for the conclusions to hold. Without development in the area of cost prediction techniques, many economic analysts are likely to continue to predict costs inappropriately, or use more time-consuming and data-intensive methods when simpler and cheaper ones may have sufficed. For example, a reduced-list costing method that identifies the main economic impacts (Knapp and Beacham 1993, Howard et al 1995, Whynes and Walker 1995) has been shown to approximate costs well, and is likely to require less research time than a prediction technique such as regression analysis. Therefore, cost prediction methods need to be evaluated in a variety of settings and compared with each other using both scientific and pragmatic criteria, so that choices can be about optimal cost prediction methods made in a variety of settings. These results, together with the results of the cost analysis review, should be used to conclude what the advantages and disadvantages of each cost prediction method are. Therefore the testing of alternative cost prediction methods and understanding their performance under different conditions are the primary aims of this thesis.

1.4 Thesis aims and outline

1.4.1 Thesis aim

The overall thesis aim is to increase current knowledge about the strengths and weaknesses of alternative cost analysis and cost prediction methods, in the context of public health care systems, and with particular emphasis on developing countries.

This thesis aim is an important one because at present the methods for conducting cost analysis to understand generalisability of costs, and methods for cost prediction, are

underdeveloped. Further research is urgently required that reviews current concepts and understanding in the literature, compares alternative cost analysis and cost prediction methods in a variety of settings, and draws conclusions about the strengths and weaknesses of alternative cost analysis and cost prediction methods.

The context of this thesis is a multi-country trial evaluating the cost-effectiveness of the W.H.O. antenatal care programme (Lumbiganon et al 1998, Villar et al 2000). Alongside this trial, a detailed costing study was conducted in Cuba and Thailand. Also, a study was conducted in South Africa to measure costs of maternity care, and to further explore issues of generalisability. Maternity care is an important health care field to research at present because it is a priority of many countries and international organisations, but there have been limited economic studies done to date to allow policy makers to choose the most cost-effective mix of interventions (Hutton 1996, Mumford et al 1998, Petrou et al 2000, Henderson et al 2000).

The thesis objectives are therefore to:

1. Review the current literature on the application of economic theory to health care costs, cost analysis and cost prediction methods, and cost analysis results, and build frameworks for analysing and predicting health care costs for use in this thesis.
2. Estimate and analyse health care costs associated with pregnancy and childbirth in study settings, to understand cost determinants and behaviour.
3. Evaluate the robustness and generalisability of these costs.
4. Test alternative methods of predicting costs, comparing cost predictions with observations of cost, and where predicted and observed cost differ, to examine why.
5. Make recommendations for researchers and policy makers concerning how to conduct and interpret cost predictions, and recommend areas for further research.

1.4.2 Thesis outline

The primary aims of the literature reviews in chapters 2 to 4 are to review current knowledge and thinking in cost analysis and cost prediction, to provide a basis for the methods in this thesis, and to compare with the empirical findings of the thesis. Chapter 2 examines health care costs in the light of economic theory. The aim of the chapter is to provide theoretical foundations in designing the cost analysis, and to provide a basis for interpreting results. The chapter summarises the production and cost functions

underlying health care processes, defines efficiency and outlines the economic relationships driving health care production and costs. The assumptions underlying perfect competition are examined in relation to the public health sector, and conclusions are drawn whether breakdown in these assumptions affects interpretation of cost and cost analysis results. The final section pulls together the material presented in the chapter by listing likely factors that determine unit cost behaviour and thus that drive cost differences between setting and over time.

Chapter 3 presents a review of cost analysis methods from the health care literature. The purpose of cost analysis in this thesis consists of explaining cost behaviour, particularly cost differences between health providers, between patients and over time. Cost analysis methods are divided into accounting methods and statistical methods. The rationale and approach of the different methods and their application to public health care institutions are described briefly. The methods are compared, with the use of examples, according to their potential and limitations for explaining cost behaviour, as well as their data requirements and ease of use.

Chapter 4 critically evaluates empirical evidence on factors hypothesised to determine cost identified in Chapter 2. Health service use, unit costs, differences in costing methodology and uncertainty are evaluated separately. The rationale for identifying the main cost determinants in advance is to provide a focus for data collection and analysis, and avoid collecting costly information on less important or irrelevant cost determinants. Therefore the chapter identifies which factors have or are likely to have the biggest influence on cost, and to judge which methods are the most useful in identifying factors. Problems are also raised concerning measurement and analysis of the factors. The results of this and previous chapters are used to conclude how costs may be predicted, whether generalising costs or making assumptions about different components of cost (health service use, resource use, or prices), or using known relationships of cost from the cost analyses to predict costs (from regression analysis).

Chapter 5 presents the thesis methods. Data collection and analysis is justified with reference to the conclusions of the literature reviews. First, the W.H.O. antenatal care trial is described. Second, the empirical objectives of the thesis are listed. Third, the data

collection and cost estimation methods are described. Fourth, cost analysis methods are described, where four levels of cost variation are distinguished: the health care provider, the treatment group, subgroups of women with different case-mix, and country. Fifth, cost prediction methods are described.

Four analysis chapters are presented. Chapter 6 presents and analyses variation in cost data in 'natural' resource units (health service use and resource use) at the four levels of variation. Significant differences at these levels are examined in terms of what factors or variables are responsible for the variation. In terms of health service use, causes are split into patient-related and provider-related, and factors identified in the review are compared between settings. In terms of resource use, staff productivity is given special focus. Other resources are compared between settings, and conclusions made about the likely causes of inter-facility and inter-country variations.

Chapter 7 presents and analyses variation in unit costs to understand variations between settings. At the within country level, differences in resource quantities are analysed, in terms of their impact on unit costs, using staffing ratios, data envelopment analysis, recalculating costs under different capacity use assumptions, scatter plots to examine whether economies of scale are present, and analysis of cost profiles (e.g. input mix). At the between country level, in addition to these methods, the roles of price differences and uncertainty in causing differences in unit costs are examined. Conclusions are made concerning how much the hypothesised factors have explained unit cost variations.

Chapter 8 presents and analyses variations in cost per pregnancy to understand variations between settings. First, the separate impacts of health service use variations and unit cost variations on cost per pregnancy are examined. Second, average cost per pregnancy for different sub-groups of women are presented and compared, using two-way tabulations, to make preliminary conclusions about which risk factors, events and health service use are the main predictors of cost. Third, multiple regression analysis is conducted to explain cost per pregnancy variations within country, and the methodological and data weaknesses and implications of the results are discussed.

Chapter 9 uses a variety of cost prediction methods to predict unit costs and cost per pregnancy between country. First, the incremental cost impact and regression methods are applied in all countries. Second, predicted costs are compared with observed costs for all cost prediction methods, and conclusions drawn about the accuracy of the methods and whether inaccuracies are economically significance. Third, the cost prediction methods are critically evaluated, and results explained. Fourth, the implications of the Cuban and Thai results are discussed with respect to which cost prediction method is most likely to be accurate for cost prediction in South Africa.

Chapter 10 discusses methodological issues and policy implications raised in the thesis. The methodological issues relate to choices that must be made in predicting costs, based on the type of cost being predicted, the source of data, and valuation issues. Also, the measures used to determine accuracy and economic significance are critically evaluated. The limitations of the cost analysis methods and results are discussed with respect to how well they contributed to an understanding of cost behaviour and cost prediction results. The policy issues discussed include how policy makers should interpret the results of the cost prediction methods, and problems associated with cost variation and cost prediction in lower-resourced settings.

Chapter 11 concludes. First, the findings of each chapter are summarised. Second, the overall empirical, methodological and policy conclusions of the thesis are presented. Third, recommendations are made for researchers and policy makers.

2 HEALTH CARE COSTS: FOUNDATIONS IN ECONOMIC THEORY

2.1 Introduction

Economic theory plays a key role in informing the producers of health services of the cost, output and/or profit options in production, and the relations between these. Economic theory is useful at different levels of decision making. For example, managers can use it to make decisions that maximise profits or welfare at the hospital or district levels, and governments or international agencies can use it to make decisions that maximise welfare at the national level. The attainment of economic efficiency is dependent on appropriate choices concerning resource use and output levels, and can be understood using cost definitions in this thesis (see Box 1.1).

In considering alternative cost analysis and cost prediction techniques, it is important to understand the neoclassical production and cost functions underlying health services. The aims of this chapter, therefore, are to provide an overview and critique of the neoclassical theory of the firm as it applies to health care costs, and to conclude whether neoclassical theory can contribute to understanding cost behaviour in public health care institutions. To pursue these aims, both microeconomic texts and health care literature are referenced. The findings of this chapter are taken forward to subsequent chapters in the analysis of costs.

2.2 The production of health care

2.2.1 Choosing 'output' in health sector analysis

To understand cost behaviour in the health sector, it is important to understand the processes underlying the production of health sector outputs. The production of the outputs 'health' and 'health care' are similar to the production of any other goods in that inputs are transformed into these outputs via a production process. The production of *health* not only requires appropriate types of health care as an input, but also other predisposing factors, such as genetic factors, life style, and environmental conditions. Therefore, it is necessarily complex to understand the production of health (Grosskopf and Valdmanis 1987). The production of *health care*, on the other hand, is simpler in that it only requires human and physical resources, and a technology (method of production) (Jacobs 1997). While *health* is the ultimate aim of the health sector, this

thesis is largely concerned with the production of the intermediate good, *health care*, and its' associated cost. While health care could be measured using detailed process and quality indicators that specify the actual contents of care, these are not easily quantifiable and comparable. Therefore, health care is represented by the quantity of health service use. This choice of output means that this thesis is focussed on 'technical' and 'economic', but not 'allocative', efficiency (Hoffmeyer and McCarthy 1996)¹⁰. However, it is implicitly recognised that such process measures have to be supplemented with assessment of health outcomes and analysis of input-output relationships to achieve allocative efficiency (Birch and Maynard 1986). This section reviews briefly the aims of production and the definitions of efficiency in the context of health care production in the public sector.

2.2.2 The aim of production

A fundamental assumption in economic theory is that efficiency is desirable, although it is often not the sole aim of human activity. A special feature of most health sectors is that they are run (at least in part) by the government or other not-for-profit organisations, and therefore their objective is not necessarily to maximise profits. Therefore the way 'efficiency' is defined, measured and interpreted differs between different providers, such as between private-for-profit, private-not-for-profit and public health care providers.

The supply side in economic theory deals with the technical or engineering rules according to which 'producing units' convert inputs into outputs, which is summarised in the production function (Heathfield and Wibe 1981). In addition, the concept of cost is at the foundation of all supply decisions, and is vital to take account of in achieving economic efficiency. This is summarised in the cost function, which is the dual of the production function (Gravelle and Rees 1992). Pragmatic considerations may lead one to ask how such knowledge of these relations helps inform the manager of a for-profit producing unit about the optimal output of goods and services. The solution to the profit-maximisation problem is reached in the following steps (Chacholiades 1986):

1. Determination of the production function.
2. Determination of cost relationships and cost minimisation.
3. Optimal output to maximise profit, given market supply and demand conditions.

¹⁰ See Glossary of Terms for definitions of efficiency.

4. Firm's demand for factors of production (land, capital and labour¹¹).

Thus, the Pareto optimal equilibrium under profit-maximising conditions can be determined on the basis of these four steps, under the assumption of perfect competition. However, several key assumptions must hold for perfect competition to exist (Donaldson and Gerard 1993, Folland et al 1994, Frech III 1996):

1. The principal aim of firms is to maximise profits.
2. There are sufficient numbers of buyers and sellers of the final good, so that no single actor has any power over the price.
3. Prices in factor markets are determined by a sufficient number of buyers and sellers.
4. The good is homogeneous; that is, all producers produce the exact same good so that the market cannot be differentiated on the basis of difference of goods.
5. There is perfect information. Buyers and sellers have the information they need on all relevant variables such as prices, quantities and utility.
6. There are no barriers to entry or exit. A producer starts producing, buying necessary machinery, patents, etc., on terms that are equivalent to those already in the industry. Also, it is costless to exit the market.
7. The good is not a public good. This essentially means that there are no externalities and it is rejectable (consumers have a choice over whether they consume the good).

'Market failure', where one or more of these assumptions do not hold, has been shown to exist in many markets (Brown and Jackson 1990). In a public health system few, if any, of these assumptions are likely to hold, and therefore perfect competition is unlikely to exist in the health care market (Folland et al 1994). The breakdown of these assumptions is important to examine because costs may behave differently under market failure than the cost relationships predicted under perfect competition. This may lead to one or more of price, resource use and health service use not being at their perfectly competitive level. In fact, if one of these is not at the perfectly competitive level (e.g. price), then it will lead to others not being at their perfectly competitive level either (e.g.

¹¹ Healthfield and Wibe (1987) defined these three basic factors of production as follows:

*Land = Inputs that exist without the intervention of man.

*Labour = The application of human effort and intelligence to bring about different states of the world.

*Capital = Land and labour invested in a production process to allow production and increase efficiency.

resource use). Therefore, the implications of market failure for the levels of price, resource use and health service use are important to examine later.

2.2.3 Technical efficiency

Technical efficiency is achieved when the maximum output is produced with a given mix of inputs. Any discussion of technical efficiency requires an understanding of the production function. Healthfield and Wibe describe the production function as “the set of possible efficient relations between inputs and outputs given the current state of technological knowledge...it is a technical relation that can be constructed without reference to market conditions or prices” (Healthfield and Wibe 1987, page 12).

Abstract models of production give the relationship between inputs and outputs in the form:

$Q = f(K, L, M, X_1 \dots X_n)$	<p>Where</p> <p>Q = the output of a particular good (in a time period A)</p> <p>K = machines used in time period A</p> <p>L = hours of labour input in time period A</p> <p>M = raw materials used in time period A</p> <p>X_n = other variables affecting the production process</p>
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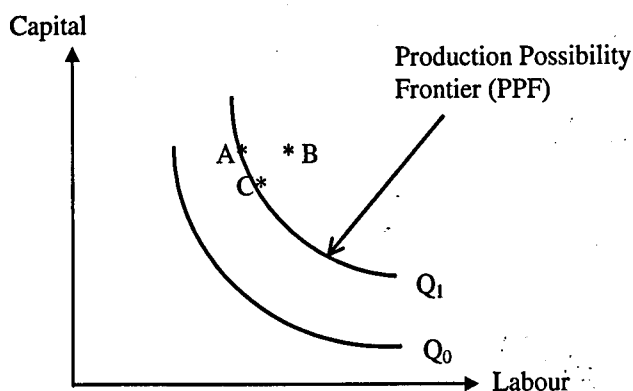
Production functions may take on many different mathematical forms, and often use a simplifying two-input assumption: capital (K) and labour (L). One commonly applied functional form that fits the theoretical patterns for such functions is called the Cobb-Douglas form, in the form: $Q = AK^\alpha L^\beta$ (where A is a coefficient, and $\alpha + \beta = 1$)¹².

The production relationship can be represented graphically using a two-input model, by combining capital and labour in different quantities (input mixes) to produce the same output. This series of combinations, the ‘production possibility frontier’ (PPF) or ‘isoquant’, is usually a single concave line (‘homothetic’) which represents the same output, shown below in Figure 2.1¹³.

¹² One of the disadvantages of the Cobb-Douglas production function is that it assumes constant elasticity, although there are refinements such as the Taylor series expansion.

¹³ The isoquants in Figure 2.1 are drawn only for values where the marginal products are greater than zero, as $MP \leq 0$ is considered ‘irrational’.

Figure 2.1: Isoquant map



In Figure 2.1, points A and C are equal in terms of technical efficiency, as they both combine capital and labour efficiently to produce Q_1 units of output. A change of production from point A to point C requires substitution of labour for capital, and the marginal rate of technical substitution (MRTS) describes the slope of the line. The concavity assumption is borne out by experience in many areas of production, and many studies providing empirical work to support the *law of diminishing returns*¹⁴, although there are instances where it does not hold (e.g. constant elasticity or no substitution).

Therefore, input substitution is the underlying assumption that drives the economic theory of production. Various substitution options between inputs also exist in health care, in both the short- and long-run. For example, nurse and doctor's hours have been found to substitute for one another (Reinhardt 1972, Folland et al 1994), as well as drugs for staff time in treating mental health patients (Jacobs 1997). However, it has also been argued that there are limits to substitution between inputs in the health sector (Barnum and Kutzin 1993, Jacobs 1997).

There are two further problems with using the two-dimensional production possibility frontiers concept in the health sector. First, the health sector employs multiple inputs, which cannot be represented graphically in more than three dimensions. In addition, resources are often differentiated within input categories (e.g. between skilled and unskilled labour). Therefore the broad categorisations used, such as labour and non-labour input, are inadequate for representing the production function. Second, hospitals

¹⁴ This law states that if more and more of a variable factor is applied to a fixed quantity of other factors, then eventually the resulting increases in output must diminish.

produce multiple outputs, and therefore ways of measuring and comparing different types of output must be used to give meaningful results from cost analysis.

2.2.4 Economic efficiency

While the production function describes the relationships between inputs and outputs, the cost function describes the relationship between outputs and costs, and therefore takes into account market conditions and prices. For economic efficiency to exist, not only must inputs be combined in such a way for technical efficiency to exist, but also the combination of inputs must be chosen to have the lowest cost among the range of alternatives. Essentially, it requires that all inputs are put to their most productive use. Economic efficiency in production will result if each firm buys or hires inputs in competitive markets and if each firm minimises production costs (Heathfield and Wibe 1981). In order to achieve economic efficiency at the firm level, input substitution occurs until the incremental value of the services from another unit of expenditure is the same for all inputs. In Figure 2.2 this occurs when the isocost line (whose gradient represents the relative prices of the two inputs) touches but does not cross the PPF corresponding to the desired output, as shown below at point B (where the slopes of the isocost line and isoquant are identical).

Figure 2.2: Isocost line and economic efficiency

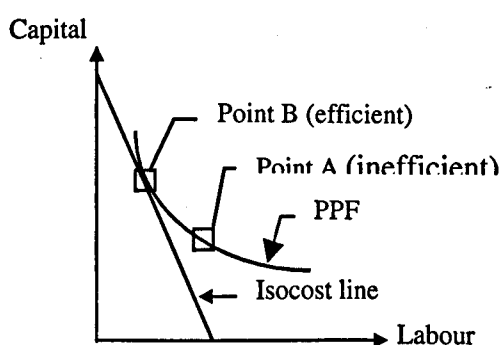
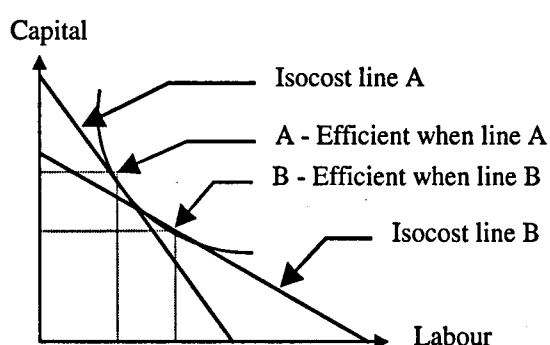


Figure 2.3: Change in isocost line



The cost-minimisation condition can be shown as: $MRTS_{LK} = MPP_L / MPP_K = w/r$, where $MRTS_{LK}$ is the marginal rate of technical substitution of labour for capital, MPP is the Marginal Physical Product, and ' w ' and ' r ' are the rents paid to labour and capital (Chacholiades 1986). This can be rewritten as: $w / MPP_L = r / MPP_K$, which means that the extra output gained per additional unit of money spent on labour and capital must be exactly the same. These efficiency conditions also apply to a multi-input production process, where the MPP and w and r are equated across all inputs.

Figure 2.3 shows the change in input mix required (from point A to point B) in order to maintain economic efficiency after a change in the relative prices of the two inputs (shown by isocost lines A and B). A way of measuring the degree of substitution between inputs is the elasticity of substitution (E_s) (Healthfield and Wibe 1987), which is a measure of the responsiveness of a cost-minimising firm to changes in relative input prices. It is defined as the ratio of percentage change in the factor input ratio to the percentage change in relative factor prices:

$$E_s = \frac{\% \text{ change in factor input ratio}}{\% \text{ change in factor price ratio}}$$

Therefore if a firm is a cost minimiser, and if it is possible to substitute between inputs, a change in relative prices would cause a shift away from the now costlier input to the now relatively cheaper input. However, there are many factors preventing the achievement of economic efficiency in the public health sector, including labour market inflexibility in the short-run, due to long training periods, staff on long-term contracts, and slow adjustments to increase capacity, thus causing E_s to be low.

2.2.5 Cost curves

Chapter 1 provided a categorisation of different types of 'cost', and concluded that several of these meanings are useful in the context of health services. These include the price of an input, the cost of a service, the total cost of treating a given patient, or the monthly/annual expenditure in a given health facility or population. This section examines various aspects of cost behaviour.

2.2.5.1 Short- and long-run

An important distinction that is made when interpreting costs is between the short- and the long-run¹⁵. The distinction between time periods is necessary because 'shocks' result in disequilibrium in the short-run due to slow adjustment of capital inputs to their equilibrium level, thus leading to higher average costs than would occur if there were immediate adjustment. Also, health care providers are subject to uncertainties about future events (such as demand), and production levels required cannot always be planned based on certain knowledge of future demand. While demand may shift rapidly,

¹⁵ This is a simplification used to present concepts. For example, Jacobs (1997) defines the short-run as less than a month, and the long-run as over a month.

supply cannot always, due to the commitments of employing resources, whether physical or human capital. For fixed inputs, the cost of capital is zero in the short-run, and therefore the associated isocost line is horizontal (I_2 in Figure 2.4). This causes the average total cost (ATC) and average variable cost (AVC) curves to converge at q_{\max} , as shown in Figure 2.5.

Figure 2.4: Short- and long-run isoquants

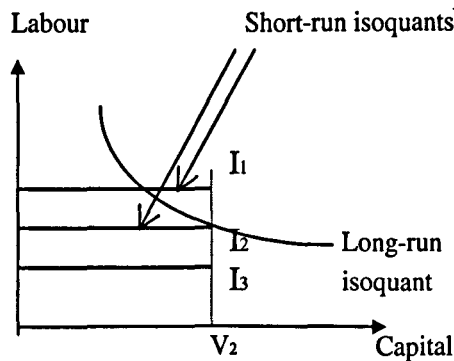
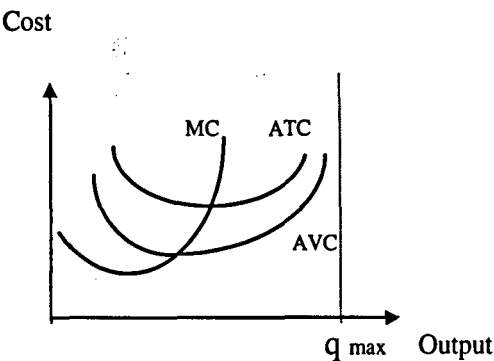


Figure 2.5: Cost curves in short-run



However, the use of two time periods has its' limitations, as adjustment may occur along a continuum, from the very short-term, such as medication use, to the very long-term, such as building construction. Some resources, such as staff and equipment may be nearer the middle of this continuum. Also, adjustment will depend on the context, and flexibility of local markets. For example, in the case of oversupply of human capital in the short-run, staff may or may not be shifted to other clinics or wards depending on whether they are short-staffed. In the long-run, decisions can be made that affect the supply of health care staff through training programmes.

The distinction between the short-run and long-run equilibrium points are shown graphically in Figure 2.6. The long-run average cost curve is the envelope of all the short-run curves.

Figure 2.6: Short- and long-run equilibrium points

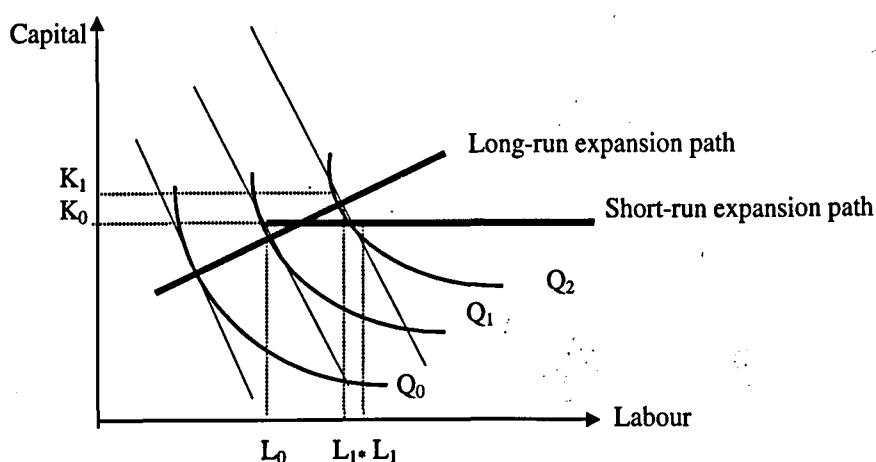


Figure 2.6 shows that in the short-run sudden changes in demand (Q_1 to Q_2), cannot be accommodated by increases in capital input from K_0 to K_1 . Therefore the increase in demand must be met by increasing labour input from L_0 to L_1 , instead of L_1^* , which would have been equilibrium point if capital had adjusted. In other words, labour input adjusts by more than it would if capital input had been fully adjustable in the short-run. This represents a movement away from long-run economic efficiency, as shown by the long-run expansion path in Figure 2.6.

An important question concerns how to operationalise the distinction between time periods (Folland et al 1994). For example, what time periods do 'short' and 'long' refer to? In the health sector, there are several time periods over which resources adjust, any time between a day and several years, and therefore more than two discrete time periods are required. Also, when observing hospitals over time, are they achieving long-run cost-minimisation?

2.2.5.2 'Economies'

A second important aspect of cost behaviour is the presence or absence of 'economies': economies of scale and economies of scope. Consideration of these relationships is important because they can explain cost variation over time and between health facilities, and help policy makers plan hospital size and health services on offer at their optimal level. Economies of scale occur when a proportional increase in all inputs of $X\%$ increases output by $>X\%$, thus reducing average costs with increases in output. Average costs reduce because resources become more productive (less input per unit of

output). An important distinction made by economists is between *returns to scale*, which is a long-run concept, and *returns to the variable factor*, which is the short-run equivalent (Chacholiades 1986). This distinction is made explicit in order to separate which factors may be causing average costs to vary with changes in output, and to recognise the different shapes of the short- and long-run cost curves. In the long-run, all inputs are variable, and are assumed to adjust to their point of maximum efficiency.

There are many factors that may be responsible for economies of scale, such as more efficient use of indivisible inputs, division of labour, and the relation between management size and efficiency. In the short-run, however, fixed costs are viewed as sunk costs (and therefore with zero opportunity cost), and are often responsible for decreasing average costs with increases in output towards maximum capacity. This concept, ‘returns to the variable factor’, was recognised by Deebie “since the costs of providing facilities are fixed, the lower the bed occupancy ratio, the higher the average cost per patient treated at constant quality” Deebie (1979, page 32). However, it should also be recognised in the provision of health care, as in other areas of production activity, that as output approaches or exceeds maximum capacity, quality may be compromised. Hence in the health care literature ‘optimal’ capacity is instead discussed, and is often taken as around 80% of maximum capacity (Luce et al 1996)¹⁶.

Figure 2.7: Total cost curve

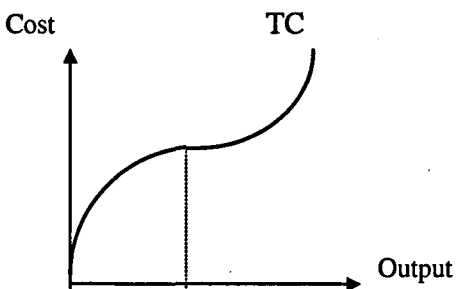
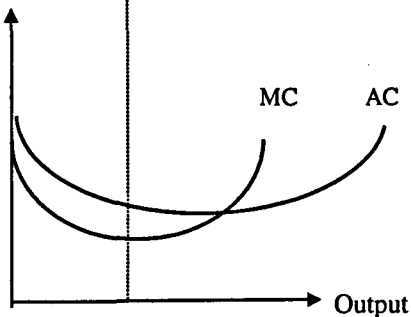


Figure 2.8: Average & marginal cost curves

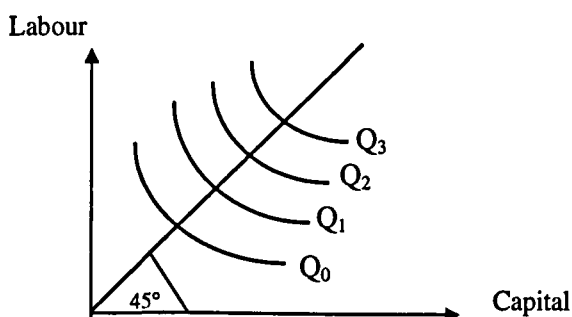


¹⁶ However, this is not due to quality considerations alone, but may also be due to demand uncertainty.

Figures 2.7 and 2.8 show the shapes of the total, average and marginal cost curves, in relation to total output, under increasing returns to scale (the downward section of the average cost curve in Figure 2.8), constant returns to scale (the stationary section) and decreasing returns to scale (the upward section).

These relations are also summarised using isoquants, as in Figure 2.9. Isoquant Q_0 represents the output in period 1. In period 2 there is a doubling of all inputs, and the output options are represented in isoquants Q_1 , Q_2 , Q_3 . Q_1 represents decreasing returns to scale, where output increases by less than double; Q_2 represents constant returns to scale, where output increases by double, and Q_3 represents increasing returns to scale, where output increases by more than double. The elasticity of scale is the ratio of proportionate increase in output to the proportionate increase in inputs.

Figure 2.9: Returns to scale.



Another type of 'economy', economies of scope, are savings derived from producing different products jointly in the same production unit rather than producing them individually in separate production units. It is often termed 'jointness' in production. This can be due to shared expertise and/or overhead expenses between service departments, or because tasks are complementary requiring a common set of capabilities.

2.2.5.3 Shifts in cost curves

Another aspect of cost behaviour is when shifts occur in the cost curve, thus changing productivity and costs. The position of a cost curve is determined by the same factors that influence the production relation, and includes case-mix, quality of care, technology, proportion of fixed factors compared to variable factors, and the incentive system under which providers operate (Jacobs 1997). Shifts occur when there are changes in economic conditions, such as changes in input prices and technological

innovation (Russell 1975, Russell 1979, Nicholson 1994), thus affecting resource use and output levels. In a two input model (L and K) a rise in the relative cost of labour will cause the expansion path of the firm to rotate toward the capital axis (assuming inputs can be substituted for one another). The extent of the shift depends critically on (a) the importance of the input in the production function, and (b) the extent of substitution possible with other inputs. New technologies also affect the expansion path of the firm.

2.3 Breakdown of neoclassical assumptions

The use of assumptions in economic theory means that when assumptions break down, cost behaviour is likely to change. The assumptions listed earlier for perfect competition to exist are examined briefly below in relation to health care provision in the public sector. When assumptions do not hold, the impact on the understanding of cost behaviour is examined. Table 2.1 summarises the findings of this section.

2.3.1 Profit-maximising behaviour.

Some form of maximisation condition must hold for production functions to have economic meaning, as the producing units must be considered 'rational' in weighing the costs and benefits of any decision (Healthfield and Wibe 1981). Barnum and Kutzin argue that "the difficulty of developing an economic view of the hospital lies in the inadequacy of the conventional profit-maximising model of the competitive market to explain the incentives, and thus the objectives and behaviour of hospital managers" (Barnum and Kutzin 1993, page 116).

Although profit-maximising behaviour is usually cited as the maximisation condition necessary for perfect competition, a weaker version – that of cost-minimisation for a given output – is often accepted (Nicholson 1994). Public sector health facilities are clearly a departure from the assumption of profit maximisation, and the following alternative models have been suggested (Cowing and Holtman 1983, Newhouse 1970, Reder 1965):

1. Maximisation of output and quality (with a given budget).
2. Minimisation of costs for a given output.
3. Maximisation of profit and output.
4. Maximisation of institutional prestige.

5. 'Satisficing' behaviour (the objective is to satisfy expectations).

While Pauly (1987) argued that the many models to explain incentives of managers in non-profit organisations have similar implications with respect to cost, others have argued that the 'prestige' and 'satisficing' behaviour models obscure the close empirical relationship between cost and output. This may be because non-profit seeking administrators, in the absence of other incentives to minimise costs or maximise output, are sheltered from competitive market forces that are responsible for economic efficiency in other types of market. Salkever (1978) introduces the 'redundant resources' theory, where top decision makers in non-profit making hospitals pursue nonpecuniary goals, such as quality or quantity of care for non-profit reasons, attracting physicians with high salaries and high technology equipment, charity care, research, and administrative slack. Also, capacity levels may be slow to adjust to changes in demand.

The implication of this debate is that there are several variables in the welfare function of 'public' institutions. For example, on the demand side policies may be made to meet patient needs, such as improving geographical access to improve uptake of services. On the supply side, providers own needs may be pursued, or their constraints taken into account, that may not exist in the private sector. Also, the way the hospital is governed has implications for the supply function. For example, autonomy over the control of sales revenue or excess budget may change behaviour, and alter the types of patient services are provided for and the quality of care. In conclusion, cost comparisons between hospitals must take into account the fact that hospitals may be pursuing different, if any, maximands, thus leading to different technologies, input mix, health services, and cost behaviour.

2.3.2 Price-taking

Buyers and sellers must be price-takers of health care services for perfect competition to exist. This means that there must be a sufficient number of buyers and sellers, and buyers must judge goods according to their prices. However, these conditions are generally lacking in public health systems, especially in developing countries. Not only are many public health services not charged for, or are provided at subsidised rates, but also the choices patients can make over which public health facilities they attend are often severely limited due to geographical and financial inaccessibility. Also, patients

reporting at health facilities outside their district may be turned away, thus reducing their ability to exercise choice in a free public health care system. Consequently, due to the lack of market mechanism in health care, it is unlikely that price or quality competition exists among public health facilities in developing countries. Therefore many services are consumed that people would not be willing to pay for if charged (whether at the market price or at cost), and important services may not be provided due to lack of sensitivity to public needs. The implication is that when estimating costs, willingness to pay and health outcomes should also be evaluated so that appropriate levels of service are provided in future. However, this point is not relevant for technical or economic efficiency as it deals with the demand side (allocative efficiency); therefore it is not studied further in this thesis.

2.3.3 Factor markets are competitive.

Perhaps an even more fundamental cause of inefficient provision of public health services is that the markets supplying the resources to produce health services are themselves rarely perfectly competitive (Folland et al 1994). If input prices do not reflect opportunity cost, then the quantity demanded, and thus health service output, will not be at optimal levels from society's perspective. Prices do not reflect opportunity cost because many of the resources purchased for use in the health sector are supplied either by the government (such as health care personnel or utilities) or prices are set by government rather than through a competitive market. For example, whether public sector salaries reflect market rates depends partly on the power of trade unions or workers. Also, the prices of imported goods may be subsidised by government, or they include the profits of distributors, with the implication that the prevailing price (border price plus carriage, insurance and freight) does not reflect the opportunity cost (Curry and Weiss 1993).

2.3.4 Homogenous output

While it is recognised that homogeneous goods are important for perfect competition to exist, considerable work has been done on the multi-output nature of hospitals, due to the differing needs of patients and the different technologies employed by health care providers. According to Folland et al (1994), a central problem in hospital cost function studies is the measure of output. This problem has at least two aspects (Tatchell 1986). First, hospitals and departments within hospitals differ with respect to the types of cases

they care for; this is called the *case-mix* problem. Health care varies according to the type of health service offered (e.g. inpatient care or outpatient care), or the patient (e.g. malaria or hypertensive). Patients differ in terms of the staff time they require, as well as the drugs and materials consumed. Researchers have constructed various types of diagnostic-related groups (DRG), according to either the type of disease or the quantity of resources used in treating patients.

Second, health care providers also differ with respect to the *quality or content of care*. This is also difficult to measure and capture in single indices for making cross-setting comparisons of cost. Health gain also varies by patient, even when costs are similar. For example, a course of antimalarials for a patient with severe malaria may not cost more than a course of antibiotics for a patient with mild flu, but the long-term health gain is likely to be considerably greater for the malaria patient. Therefore, hospital managers must decide what their optimal mix of health services is, making a trade-off between outpatients, inpatients, surgery, etc. The implication is that the heterogeneity of health services is important to take into account when interpreting costs, or comparing costs across settings.

2.3.5 Perfect information

The requirement of perfect information for perfect competition to exist applies to both the consumer and provider of health care. Consumers are assumed to be fully informed and knowledgeable, and therefore possess the ability to seek out the producer with the lowest prices, as well as knowing what they want and when they want it (Donaldson and Gerard 1993). However, in health care systems, all actors are subject to some form of information shortage. Consumers rely on the 'agency relationship' with providers, who may face incentives not to maximise consumer welfare due to financial incentives or resource constraints. Also, managers do not know with certainty the demand for the coming period¹⁷ or the full range of suppliers who could undercut the prices of current suppliers, and the non-storage properties of health services results in wasting resources. The result of the breakdown in perfect information is that patients do not seek care at the right time or do not receive the optimal treatment, and often health services cost more due to demand uncertainty and subsequent wastage. Therefore, these issues must be taken into account in interpreting costs, and comparing costs between settings.

2.3.6 Barriers to entry and exit

The assumption that producers can enter and leave the market costlessly is obviously unrealistic for most markets, where investment is required in capital items and stock, as well as the existence of liquidation costs. In the short-term, there are significant barriers to the entry and exit of public providers of health services. The problems are less related to barriers existing in private markets such as sunk costs, but more to the bureaucratic and political processes of agreeing to open or close hospitals. For example, when there is oversupply of hospital beds, many non-economic arguments may be put forward in support of keeping hospitals open, thus leading to bed capacity levels that perhaps would not exist in the private sector. Also, governments are limited only by their ability to raise taxes or use debt to finance 'uneconomic' hospitals. This over-capacity leads to higher cost per service (due to low occupancy rates), which should be taken into account in interpreting cost data. Alternatively, if there are insufficient hospitals, bed occupancy may be above 100%, leading to lower unit costs, but also a decline in quality of care if there are insufficient staff and drugs. Whichever occurs, the slow adjustment process that characterises many public hospitals means that average costs vary from the rate they would be at if hospitals were operating at 'optimal' capacity.

2.3.7 Public good characteristics

Health care has been argued by many to be a public good, due to positive externalities (such as immunization programmes) and its associated non-rejectable nature (Donaldson and Gerard 1993). These are some of the arguments used to advocate the public provision of health care, as it would be under-provided by a private market. Therefore the public good characteristics of some types of health care mean that perfect competition does not exist in some health care markets. The implication is that, from a societal perspective, externalities should be included in cost measurement (if quantifiable).

2.3.8 Conclusions

The presence of several types of market failure means that health care provision in the public sector is a clear departure from perfect competition. Table 2.1 summarises the findings above concerning the breakdown of neoclassical assumptions in the public health care market. The implications for cost interpretation is that there are potentially

¹⁷ Although it can be controlled using waiting lists for some health services such as elective surgery.

several causes of cost difference between health facilities: inefficiency, incorrect value, case-mix differences, product or quality differences, (dis-)economies of scale and scope, and differences in capacity use. The next section formalises these causes of cost variation into a framework for use later in the thesis.

Table 2.1: Implications for cost interpretation of breakdown in neoclassical assumptions.

Assumption	Breakdown of assumption?	Impact of breakdown on cost interpretation
1. Profit-maximising behaviour	Yes. Public hospitals have several goals, and profit maximisation is rarely among them.	If an acceptable maximisation condition does not hold, cost comparisons between hospitals must take into account varying levels of inefficiency. Affects price, resource use, and output, and thus average cost.
2. Price taking	Yes. Services in public hospitals may not be charged for (at market rate). Thus demand does not equal WTP.	Costs should be interpreted alongside data on willingness to pay and health outcomes. Affects output, and thus average cost.
3. Factor markets are competitive	Yes. Salaries are lower in public sector, while other inputs are taxed or subsidised.	Unit cost may not reflect opportunity cost, and therefore adjustments should be made, or interpretations should take this into account. Affects price, and thus resource use and average cost.
4. Homogeneous output	Yes. Patients vary by case-mix and the care received.	Cost analysis should take into account case-mix differences, which may affect prices and resource use.
5. Perfect information	Yes. Agency relationship and clinical and demand uncertainty.	Affects price, resource use, and output, and thus average cost. Lack of perfect information may lead to technical inefficiency (wastage of resources) or allocative inefficiency (unnecessary health care).
6. No barriers to entry and exit	Yes. Bureaucracy delays opening/closure; sunk costs.	This leads to under- or over-capacity, with an impact on average cost and quality of care.
7. Public good characteristics	Yes. There are positive externalities to some health services.	-

2.4 Implications for analysing cost variation

This chapter has briefly explored the relevance of economic theory for the supply of health services, and discussed determinants of cost behaviour, as suggested by economic theory. Using the conclusions of previous sections of this chapter a list of factors is constructed to explain inter-setting differences in costs, to be used in later chapters in reviewing the cost analysis literature. Unit cost can be disaggregated by its' two component parts – resource quantity and resource price.

Unit costs may vary due to quantity differences for the following reasons:

1. Level of X-inefficiency, where the producer is operating off the average cost curve. This may be due to institutional factors (e.g. rigidity in workforce, over-specialisation of skills, or lack of accountability), inappropriate usage (inefficient use of labour, equipment, drugs) or pure wastage (loss, theft, staff absence).
2. Returns to the variable factor, where increases in throughput result in lower average costs due to spare capacity. This is because when throughput increases from one time period to another, fixed costs are spread over a larger patient throughput.
3. Economies of scale, where increases in capacity levels results in lower average costs. This may be due to greater division of labour, greater productivity of capital assets, or other economies that result when large size can be exploited (e.g. bulk purchases).
4. Economies of scope, where more types of health care or support service influence average costs.
5. Input mix, where relative resource intensity varies due to technology, teaching status, 'level' (e.g. primary or secondary), and ownership, thus influencing average costs.
6. Quality of care, where different quality of care influences average costs. *Ceteris paribus*, better quality services cost more due to the extra cost of improved management practices, and resource intensity.
7. Case-mix, where more severely ill patients cost more, due to the higher intensity of resource requirements, and longer average length of stay (ALOS).

While economic theory provides a theoretical basis for comparing production functions and understanding cost differences, two qualifications are worth mentioning, to allow correct interpretations of differences in input use between producing units. First, differences in substitution options and modes of health care delivery between countries means that input mixes can vary greatly, thus causing differences in costs. Therefore, differences in staffing ratios between countries do not necessarily indicate that some are inefficient, because they may all be achieving efficiency, but by different methods depending on local practice style. Second, health systems being observed at one moment in time may not be efficient, but may be moving towards efficiency. Therefore, the speed of adjustment is also an important issue in the health sector, and it depends on several factors. These include whether the resource can be stored, the quality of communication between decision makers and those implementing policy, and the

availability of resources or additional funds to make required changes (Barnum and Kutzin 1993).

Prices have been found to influence average costs, in two ways:

1. Absolute price change or difference. Input prices and costs are positively correlated, so that in a static analysis an $x\%$ increase in prices should lead to an $x\%$ increase in the costs associated with that resource. However, under a fixed budget, resource use will decrease. Unit costs may also vary because in one setting financial costs are used, and in another opportunity costs.
2. Relative price change or difference. Where input substitution exists, an increase in the price of one input of $x\%$ will decrease the use of that input, thus meaning costs will not increase as much as $x\%$. This will depend on several factors, including the price elasticity of demand, the cross-price elasticity of demand, budget flexibility, the incentive for managers to adjust resources to new levels of supply and the speed of this adjustment, and the presence of government regulations and procedures.

These hypothesised causes of cost variation are taken forward to Chapter 4, where the cost analysis literature is reviewed, to conclude how important these causes are, and what the data requirements are for cost analysis (with implications for whether they can be studied in data-constrained settings such as developing countries).

3 METHODS FOR EXPLAINING COST BEHAVIOUR

3.1 Introduction

Researchers working on the allocation of resources in health care have been examining the behaviour of costs for several decades (Lave 1966, Mann and Yett 1968, Hefty 1969, Berki 1972, Jacobs 1974, Feldstein 1974, Cowing et al 1983, Creese et al 1988, Mills 1990, Newbrander et al 1992, Barnum and Kutzin 1993, Butler 1995). Two principle reasons can be distinguished why understanding the behaviour of costs in the health sector is important. The first reason concerns what the objective, or 'maximand', of each individual health facility is, discussed in more detail in Chapter 2. For example, private health facilities will choose the types and quantity of health services to maximise profits. In public health facilities, the objective may be to maximise hospital output with a given budget. For both of these, a knowledge of cost levels and behaviour through cost analysis are essential inputs to achieving these objectives. The second reason, as described in Chapter 1, concerns the need of researchers and policy makers to predict costs when cost data are not available or cannot be collected in the setting(s) where resource allocation decisions are made. Knowledge of cost determinants aids the cost prediction process, making it simpler and more accurate than when cost behaviour is not understood.

However, understanding cost behaviour in the health sector has proved in the past to be a challenge, as there are numerous factors that simultaneously determine or influence cost, and which act differently across health care settings (Cowing et al 1983). In addition, as this chapter argues, the greater the required confidence in the conclusions, the greater the need for good quality data sets and cost analysis methods. Thus a range of cost analysis methods have been developed to explain cost behaviour in diverse settings. These methods have been classified in the literature as two types - 'accounting' and 'statistical' methods (Sherman 1984, Barnum and Kutzin 1993, Ehreth 1994, Mahapatra and Berman 1994). Barnum and Kutzin (1993) describe these as "...complementary tools to examine internal efficiency issues and to generate a cost basis for planning and cost-recovery policies".

A search was made of the theoretical and empirical cost analysis literature relating to health care¹⁸. The search found several papers, books or book chapters that used or discussed alternative cost analysis methods, although few of these provided an overview of their strengths and weaknesses. This chapter, therefore, aims to evaluate alternative methods for cost analysis, explaining their basic methodologies and application to public health facilities, their strengths and weaknesses in explaining cost behaviour, and practical issues such as their data requirements and ease of use. In particular, how the methods distinguish between the different components of cost described earlier (price, resource use and health service use) is examined. The empirical findings of these studies are discussed in Chapter 4.

3.2 Accounting methods

3.2.1 Introduction

The aim of this section is to review ‘accounting’ methods of analysis that have been used for identifying causes of inter-setting cost variation. These methods cover a broad range of indicators for evaluating the performance of health care providers. They have been called by different names in the literature, including ‘ratios’ (Sherman 1984), ‘performance indicators’ (Lasso 1986, Birch and Maynard 1986) and ‘performance assessment framework’ (Leggat et al 1998). The use of accounting methods varies according to the purpose of the analysis. On the one hand, Sherman describes ratio analysis as “the use of various ratios for a group of comparable hospitals to locate relationships that are abnormally high or low, such as cost per patient day, cost per patient, and personnel full-time equivalents per patient” (Sherman 1984, page 924). On the other hand, the Canadian Council on Health Services Accreditation define a performance indicator more specifically as “a measurement tool, screen or flag that is used to monitor, evaluate and improve the quality of client care, clinical support services and organisational functions that affect client outcomes” (CCHSA 1996, page 76). The lack of comprehensive model to date is not surprising given differences in aims and nature of health provider organisations and researchers (Leggat et al 1998).

¹⁸ Cost studies were searched using Medline, Popline, and Bids databases for all years available. Studies were retrieved that explicitly stated in their abstract that different aspects of cost profile were presented or some form of cost analysis was done to understand the determinants and behaviour of costs.

This thesis leans towards the Sherman (1984) definition, as it deals mainly with explaining variations in cost per service or cost per patient. Accounting methods reviewed below include the use of cross-setting data substitution, resource and cost profile analysis, efficiency analysis, scatter plots, and output profiles. The main characteristics are summarised in Table 3.1 in the concluding section. Financial indicators are not reviewed because they are of limited use in public health facilities (Leggat et al 1998¹⁹), especially in developing countries where many resources are donated.

3.2.2 Cross-setting data substitution

The rationale behind data substitution is that differences between settings can be examined one at a time, and impact on costs and cost differences found. It uses the technique of sensitivity analysis, except that the ranges tested reflect the likely values from other settings as opposed to the range of uncertainty in the setting of the study. Differences in price, resource use or health service can be examined one at a time or in combination. For example, the impact of price differences between two countries on unit cost can be examined by substituting the prices of one country in the calculations of the other (Butler 1995). The same technique can be applied to other types of data, such as resource use per visit. For example, staffing ratios from one health facility can be applied in another facility to see whether average costs converge. Data substitution is a simple technique, and has minimal data requirements, but is a potentially powerful way of identifying major causes of cost differences between settings.

While data substitution can indicate the main sources of variability, it is not entirely reliable in understanding causes of difference between settings. Butler (1995) points out that the weakness of substituting data is that it is a static framework, and does not take into account dynamic interactions that may occur as a result of the given substitution. For example, when the relative prices of resources vary between countries, simple substitution does not take into account input substitution that may occur to maintain economic efficiency. This concern challenges the usefulness of cross-country data transfers, as relative prices are likely to vary between any two countries due to the different import prices they face (Robertson et al 1991).

¹⁹ Such as cash flow to total debt, long term debts to fixed assets, profit margin, asset turnover, etc,

A second weakness concerns the fact that resources are defined differently in different settings or countries. The calculation of relative prices depends on which resource categories are chosen to represent the price level of a country, unless a weighted average is used. For example, for comparing the relative prices of equipment and staff, which type of staff is chosen to reflect salary levels depends on the relative importance of different staff categories in health care in the country of interest. A third potential weakness of the data substitution approach is that it requires adequate disaggregation of prices, resource use and health service use quantities to make the comparisons and allow costs to be recalculated.

3.2.3 Resource and cost profiles

Profiles essentially consist of different ways of tabulating data to gain further insight into the composition of cost. Profiles are recognised by W.H.O. as an important means for programme managers “to understand where the burden of cost falls, shifts in the burden of cost over time, and variations in cost between settings” (W.H.O. 1979, page 21). Profiles provide ways of presenting data that help the analyst understand cost composition, and thus helps to identify causes of cost variation. They are easy to interpret if the data are of good quality and disaggregated. Profiles can be in both monetary and non-monetary forms. The former has the advantage that resource use is compared in identical units in both aggregated and disaggregated forms. However, physical quantities also have their uses, for both planning and generalisability purposes. For example, managers may wish to know the requirement for certain resources or types of health service which are in a fixed supply in the short-run. For generalisability purposes, the costs of a health care intervention can be built from physical ingredients (resource use and health service use) and then applying local prices in the country where primary data are required, as opposed to transferring dollar costs across international boundaries. However, note that there may be qualitative as well as quantitative differences between resources and health services, thus reducing the generalisability of physical quantities across health care settings.

The W.H.O. guidelines for cost-effectiveness analysis of vector control (Phillips et al 1993) recommended presenting the following cost profiles to help health service planning, although these are also essential for making cost predictions:

1. Recurrent cost and capital costs, by resource type (cost ‘ingredients’).

2. Marginal cost and non-marginal (sunk or fixed) costs.
3. Foreign exchange cost and local currency cost.
4. Current cost and future cost.
5. Health care and non-health care (management and overhead, training) activities.

In addition to these five, if a health care programme involves several types of care, the location (fixed clinic, mobile clinic) and type of care (inpatient, outpatient, etc) can be provided separately. These profiles are combinable in different forms to provide further information for planning and cost prediction purposes. For example, the relationship between unit cost and health facility size can be suggested by looking at the proportion of overhead cost in unit cost: if large health facilities have lower % overhead cost, economies of scale may exist.

To understand cost variation between settings or over time, a range of profiles will need to be presented, according to the objectives of the health planner, the nature of the health care intervention, and the data available. The lack of routinely available data can present problems. In many settings in developing countries, for example, capital cost data for items more than a few years old and foreign exchange cost data are not easily available. A weakness of 2-way tabulations in explaining costs is that other factors causing cost differences between setting may not be taken into account, leading to biased estimates of variation. A point raised in Chapter 2 was that higher unit costs may have been due to case-mix differences instead of efficiency differences. This could have been due to one or a combination of a more intensive use of staff, drugs or materials, and equipment. Therefore, the potential effect of these other factors must be identified to allow appropriate conclusions (sections 3.2.6 and 3.3.2 discuss in more detail how output differences can be examined).

3.2.4 Efficiency scores

Efficiency scores essentially compare input(s) with output(s), and thus identify whether slack exists, or is likely to exist. Like cost profiles, efficiency scores can also be measured in both monetary and non-monetary (natural) units. In monetary units, the waste due to inefficiency is identified in money value, and total size calculated, giving a measure of absolute and proportional wastage (Zuckerman et al 1994). The main focus in the health care literature is on staff inefficiency, where unproductive staff time is

estimated, converted to money units using salary rates, and compared with the budget or operating costs of a health facility or the total wage bill. For example, Lewis et al (1996) found that the operating budget in one hospital in the Dominican Republic was 50% higher than the actual costs of service delivery due to “waste, down time or other extra-hospital activities...suggesting a high degree of inefficiency as well as low staff productivity” (Lewis et al 1996, page 228).

Zuckerman et al (1994) developed the concept of ‘minimum feasible cost’ (MFC), where input wastage or inefficiency is identified and subtracted from the total cost. Their measure of inefficiency (I) was: $I = TC_{MFC} / TC_A$ where a value of 1 indicates economic efficiency. TC_A is the total cost incurred by the health facility in normal operations. TC_{MFC} is the cost when the maximum productivity is obtained from all inputs, and inputs are employed in their cost-minimising combinations. They identified wastage of staff time by interviewing the heads of departments about the amount of underemployment that existed, and whether lower skilled staff could substitute for higher skilled staff. Also, materials and drugs that had gone missing were estimated by interviewing storeroom staff. However, to collect these data requires intensive study, and suffers from the drawback that the supplier of information is often the one being evaluated for efficiency, creating incentives to withhold information.

Many types of inefficiency have been found and quantified in the literature, although the MFC has not been calculated in many studies. For example, in a study of sexually-transmitted disease treatment in Malawi, Daly et al (1998) estimated the cost of drugs used ineffectively or at the wrong dosage, and found that they accounted for over 50% of total drug cost. ‘Time-without-specific-activity’, which suggests unproductive time, has been used in several studies (e.g. Lewis et al 1991, Bryant and Escomba 1995, Mills 1989). However, in none of these studies was the value loss explicitly quantified in money units, nor the likely impact on unit cost identified. Most studies examined one resource at a time, as opposed to several resources simultaneously. Also, except through direct observation (Bryant and Essomba 1995) there limited alternative means of measuring the level of wastage using retrospective recall, especially from staff who are partly responsible for the wastage, or when researcher observation changes the way providers operate (the ‘hawthorne’ effect).

There are also several types of non-monetary efficiency measure, in the form of ratios, which allows cross-setting comparisons. The most commonly used are input/output ratios – such as staff per outpatient visits, staff per bed day, staff minutes per patient. Staff time is measurable in terms of the full-time equivalent (FTE), and has the advantage that FTEs can be compared across currency boundaries without having to make interpretations based on the currency exchange method. However, this leads to problems when different types of staff are combined in the FTE measure. One example of staff per patient ratios was Fryatt et al (1996), who tabulated the number of staff per 100 treated tuberculosis cases in Nepal, and also numbers of suspected tuberculosis cases screened per staff. Although they did not compare these ratios with unit costs, they did show large variation in ratios between programmes operating in different districts.

Another non-monetary efficiency measure is the rate of capacity use, such as occupancy²⁰. If a health facility has a considerably lower occupancy than others, this is likely to cause unit cost differences (Berman 1994, Robertson et al 1984, Robertson et al 1992). The average length of stay (ALOS) is also an important indicator of the efficiency level of a health facility, although ALOS should be compared for similar case-mixes for the comparisons to be meaningful. The Data for Decision Making project (DDM 1997) used occupancy rate, average length of stay²¹ and bed turnover rate²² to explain differences in average costs between hospitals in Egypt. The correct interpretation of these measures has gained some attention in the literature. For example, Lasso (1986) developed an analytic method for evaluating hospital performance through simultaneous application of these indicators, by plotting them on a graph in order to make conclusions about the comparative performance of groups of hospitals. In isolation these measures provide useful information, but their explanatory power is increased when they are used together²³.

²⁰ Bed Occupancy = (Total inpatient days used) ÷ (Total inpatient days available)

²¹ Average Length of Stay = (Total inpatient days used) ÷ (Total admissions)

²² Bed Turnover Rate = (Number of admissions) ÷ (Number of beds)

²³ Lasso (1986) plotted bed occupancy on the X axis and turnover rate on the Y axis; average length of stay can be shown by drawing a straight line out from the origin to the point plotted for bed occupancy against turnover rate. Each graph is divided into four sectors, the borders of which are defined by the average bed occupancy and turnover rate, and the hospitals are judged according to the general features of each sector (see text).

A further method for examining the impact of differences in capacity use on unit costs is to recalculate unit costs based on the assumption that a provider is operating at the optimal bed occupancy (quoted at 80% by Luce et al 1996), and compare it with actual unit cost. Once this influence on average cost has been shown, the true impact of remaining cost determinants such as X-inefficiency can be identified. In outpatient services, this method requires an estimate of the potential throughput of outpatients, as no traditional measure of potential output, such as bed availability, has been used.

3.2.5 2-way relationships

Diagrams such as scatter plots and bivariate analysis (2-way correlations) are useful for showing 2-way tabulations of variables that may be related to each other. A much tested relationship in the literature is that between average cost and health facility size, to see whether economies of scale exist, usually done by visual inspection but also the Pearson correlation coefficient can be calculated to identify whether the correlation between average cost and size is statistically significant. For example, Robertson et al (1992) plotted average cost against vaccinations per session at 20 sample sites in The Gambia, and concluded that average costs is inversely related to the vaccinations per session and also to the vaccinations per year. Also, Jian et al (1998) found a steady fall in average cost with increased output, suggesting that the number of accessible children was a more important determinant of programme cost differences than other factors. They concluded that provinces with higher output had the lowest average costs per vaccination, due mainly to economies of scale.

However, there are potential problems with making conclusions from these scatter plots. The first problem concerns the “regression fallacy” when making conclusions about economies of scale. This was recognised by Friedman: “insofar as size itself is measured by actual output, or an index related to it, a much more serious bias is introduced, tending toward an apparent decline in costs as size increases” (Friedman 1955, page 236)”. Therefore, if actual inpatient days are used instead of number of bed days available, there may be a misleading indication of the existence of economies of scale. However, the best means of testing for economies of scale, that of observing the impact of equi-proportional increase in inputs on output, can rarely be observed within a single health facility. The next best is to compare carrying capacity across health facilities, and tabulate with average cost. This raises the second concern with 2-way comparisons: that

they fail to account for other confounding (or multiple) factors. If the health facilities are not homogeneous in all other ways, then the link between average cost and size is not a certain one. For example, bigger hospitals tend to have more services available, or may be a teaching hospital, thus bringing confounding variables into the equation. This requires multiple variable analysis, which is best dealt with in regression analysis.

3.2.6 Output profiles

It has already been suggested in Chapter 2 and in the previous sections that output heterogeneity may 'confound' simple cost analyses, thus reducing the strength of conclusions possible from 2-way comparisons described above. Tatchell (1983) argued that hospital output measurement has rarely been tackled directly in explaining cost differences, although there have been considerable developments since the time of the article. 'Output' has both a demand and supply side. The demand side concerns the illness or severity of the patient ('case-mix'), while the supply side concerns the quality of care or the range of services provided (often termed 'scope').

Differences in case-mix as a cause of cost variation have been examined in many studies, and are important because they can cause both unit costs and case costs to vary between patients or settings. The source of the variation in unit costs may be both resource use and prices (for example, more severe case-mixes may require more specialised equipment or staff), while health service use differences may also contribute to higher case costs in more severe cases. Considerable attention has gone into classifying case-mix using the International Classification of Disease (ICD), Diagnostic Related Groups (DRG), information theory, case severity and specialty mix measures (these were reviewed in Tatchell 1983). For example, Evans (1971) uses ten case-mix factors and six age-sex factors to compare average costs between 185 acute care hospitals in Ontario, and concludes that it is important to classify patients by case-mix to make a meaningful analysis of average costs. The ability of the measures identified by Tatchell to explain unit cost difference varies. Some measures classify disease by area of the body, and are not specifically linked to resource input requirements. On the other hand, the DRG classification system was developed specifically to classify patients in homogeneous categories of clinical management, therefore approximating resource use. However, because hospitals manage patients differently, and treat different case-mixes, DRGs may not provide a sound basis on which to represent costs. An alternative

approach is that unit costs can be tabulated for patients with different key events, such as an operation or a morbid event, and therefore identify the main cost determinants, as done by Butler et al (1995) for cancer patients.

On the supply side, methods for measuring quality of care are less well developed, although higher quality care also potentially affects costs through different prices, resource use and health service use. Methods for measuring quality of care also suffer from definitional problems. Quality has been defined as both a process and as an outcome indicator. Process indicators can be structural, defined by what resources and health care are available (Gilson 1992). For example, Lewis et al (1991) and Broomberg (1997) both gave quality scores based on the sufficiency of time devoted to patients and to supervision of residents, as well as availability of capital items required for minimum standard health care. Robertson et al (1991) used a variety of quality indicators, identifying health facility structure, cost profiles and health care processes, and using a questionnaire to health care personnel to determine the existence of standards or norms of medical practice, knowledge of these standards, and adherence to them. Structural quality also measures the facility mix, which is used to identify whether or not economies of scope exist. Tatchell (1986) distinguished between 'facilities and services offered' (used in Carr and Feldstein 1967) and 'services actually performed' (used in Watts and Klastorin 1980).

3.2.7 Conclusions

The methods described above have been used to examine many aspects of cost behaviour, and they cover all three components of case cost, namely prices, resource use and health service use. However, it was rare in the studies reviewed to draw the link between cost determinants and actual unit costs; that is, there were no statements such as "the cost determinant 'X' explained Y% in cost variation". However, this is more likely to be due to inadequacy in the methods as opposed to inadequacy in the application of the methods, as Sherman points out: "...as each ratio is by nature limited to one input and one output, it cannot easily accommodate situations where multiple outputs are produced using multiple inputs...higher costs per patient day could be due to the case-mix, higher prices, or higher intensity of resource use" (Sherman 1984, page 924). Therefore the interplay of cost determinants suggested above means that cost determinants can rarely be identified as having a constant percentage impact on cost.

Leggat et al (1998) also warned that these methods are only as strong as the data underlying them, and therefore results must be interpreted with this in mind. The methods are summarised in Table 3.1, in terms of what each method can explain, the data required, and the limitations of the method in explaining costs. Despite the fact that accounting methods of cost analysis are generally static, they do allow detailed examination of some cost determinants (and cost components). This allows early conclusions concerning which cost components are driving the cost variations observed, and thus these components can be examined in greater detail. The importance of this analysis becomes greater when statistical analyses are not performed to allow additional interpretations of cost differences.

The results of this section on accounting methods suggest that, while each method can be informative, a fuller picture is built of cost behaviour by comparing and contrasting the results of more than one method simultaneously (such as the 'Lasso' method described above). There has been limited work in this area, especially for outpatient care, and further testing and refinement is needed, especially as the use of regression analysis cannot be relied upon given its' data requirements (see next section). As well as data deficiencies, methods for tabulating output measures with costs were shown to suffer from definitional uncertainties and stringent data requirements. Despite these deficiencies, ratio analysis is a commonly performed technique for analysing cost data, and allows preliminary conclusions about the causes of unit cost variation, before investing further time in statistical analyses.

Table 3.1: Summary of methods, uses, data requirements and limitations of accounting methods of cost analysis

Method (with examples of applications)		What can be explained	Data requirements	Limitations of methods
Cross-setting data substitution	Prices	Extent to which price difference causes cost relevant difference	Price and resource quantity data in all settings	Doesn't allow for input substitution; requires disaggregated data; requires choice of inputs
	Staff ratios	Extent to which staffing pattern difference causes cost difference	Staffing ratios, staff costs, % direct costs	Training and roles of staff may differ between country
Cost profiles	Cost ingredients	Which resources are driving cost differences	Data on cost of all inputs	Requires detailed data often not available, method should not be used in isolation
	Recurrent/capital	Budget implications of change in health care provision	Separate recording of capital costs	Requires detailed data often not available, method should not be used in isolation
	Local / international currency	Importance of imports in cost; impact of OER fluctuations	Separate recording of imported costs	Requires detailed data often not available, method should not be used in isolation
	Health care / non-health care	Economies of scale	Direct and 'allocated' costs	Requires detailed data, method should not be used in isolation; not definitive proof of EOS
	Primary / secondary; inpatient / outpatient	Optimal budget allocation between and within health facilities	Breakdown of cost by location	Requires detailed data often not available, method should not be used in isolation
Resource profiles	Minutes per patient	Quality of care and staff use	Contact time with patient	Requires detailed data collection
	Drugs per patient	Drug availability and usage	Prescription patterns	Requires detailed data collection
Efficiency scores	Minimum feasible cost	Costs that could be saved by improving efficiency	Wasted resource quantity, prices of resources	Requires detailed data collection
	Occupancy	Impact of throughput on unit cost	% ward or clinic occupancy	How to define and measure 'occupancy'
	Time-without-specific activity	Proportion of time unaccounted for	Time diaries and resource prices	Requires detailed data collection
	Staff ratios	Quality of care, staff use efficiency	Staff and patient numbers	Does not prove (in)efficiency in isolation
	Equipment ratios	Quality of care, eq. use efficiency	Equipment and patient numbers	Does not prove (in)efficiency in isolation
	Average length of stay	Quality of care, cause of occupancy	Number of days per patient	Does not prove (in)efficiency in isolation
	Unit cost at 100% capacity use	How much unit costs change with throughput	Marginal cost, throughput levels, maximum throughput	Maximum t'put levels in OPD more difficult to define; 100% capacity may not be optimal
2-way relationships	Scatter plot or bar charts	Economies of scale, teaching status, case-mix	Unit costs and potential output, unit costs by case-mix	Not definitive proof of EOS or other factors; requires large data sets
Output profiles	Case-mix	Causes of unit /case cost variation	Diagnoses/treatment of patients	Definitional and measurement problems
	Quality of care	Causes of unit cost variation, health outcomes, health service utilisation	Structural / perceived quality, health care content, outcomes	Definitional and measurement problems and impact of confounding variables

3.3 Statistical methods

Two principal types of technique are reviewed in this section, namely econometric techniques and data envelopment analysis. These represent two important statistical techniques used in the literature for examining hospital production and cost relations.

3.3.1 Regression analysis

Introduction

Econometrics, the application of regression analysis to economics, has long been used to estimate hospital cost and production relationships (Sherman 1984). In the context of cost analysis, the purpose of regression analysis is two-fold

1. To understand the causes of variation in cost by relating them explanatory variables.
2. To use the results of 1. to make predictions of what values the variable of interest may take in other settings.

Econometric models are used because they can provide a better explanation than ratio analysis of how average and total costs change in response to differences in service mix, inputs, input prices and scales of operation, among others (Barnum and Kutzin 1993). Only statistical techniques can separate the effects of simultaneous variations on cost, and interactive effects of variables, such as quality, length of stay and occupancy rates (Deeble, 1979).

In conducting regression analysis, several aspects of the regression need to be decided, namely the variable of interest (dependent variable), the variables hypothesised to influence or determine the variable of interest (independent variables), the model relating these, and the data sources. In building and interpreting the model, several guiding principles recommended by econometricians should be noted (McCloskey and Zilliak 1996, Gujarati 1999): (1) keep the model simple (i.e. 'parsimoniom') to capture the most important features of reality; (2) describe and justify the range of independent variables and the units of measurement; (3) transform the data to meet the distributional assumptions of the model; (4) aim for reasonable goodness-of-fit of the model; (5) compare the signs and sizes of estimated coefficients with those expected from economic theory; (6) meet the conditions for best-linear unbiased estimators (BLUE). Important aspects of model building and interpretation are covered in turn below.

Choice of dependent variable

Three main types of cost have been analysed in the econometrics literature within the health sector (refer to Appendix 1 Tables 1.1 to 1.3). These are total cost (usually for a hospital or hospital department), average cost (per visit, per day), case cost (per event, per admission)²⁴. The bulk of the early literature focussed on average and total costs, with increasing interest recently in case cost. The dependent variable chosen depends on which relationships are being examined, as well as the sample size. For example, if the hospital is the unit of analysis, and sample size is greater than about 30, average or total costs should be the dependent variable. If the impact of multiple patient factors is also of interest, then case cost can be the dependent variable instead. The advantage of having case costs or total costs as the dependent variable is that it incorporates all three cost components: prices, resource use and health service use. Average cost, on the other hand, does not include health service use within it. A further advantage of having case costs as the dependent variable is that the influence of patient characteristics on cost can be evaluated at the individual level as opposed to the aggregate (or average) level.

Choice of independent variables

The first criterion for selecting independent variables is the hypothesis that they are related to the dependent variable. The model specification must be consistent with economic theory to give meaningful results. Cowing et al (1983) argue that the lack of a theoretically consistent framework in earlier studies of hospital cost meant that erroneous interpretations were made about the existence of cost relationships. Various categories of independent variables have been quoted as important to include in regression equations to avoid mis-specification, including (Cowing et al, 1983):

1. Variable(s) to represent the multiple-output dimension of hospital care.
2. Price variable(s) when prices vary.
3. A variable to represent whether a physician admits patients to hospital (this reflects the concern of supplier-induced demand in some countries).
4. Variable(s) to represent economies of scale and scope.

²⁴ In addition to monetary cost being the dependent variable, health service use has also been evaluated, such as the determinants of length of stay. For example, Elliot (1997) examined variation in the length of stay following nosocomial infection, and Khoshnood (1996) the length of stay in neonatal intensive care units.

5. Variable(s) to represent differences in incentives between the public and private hospitals.

Subsequently, the regression literature has focussed on teaching status, hospital, ownership, case-mix, and size (see Appendix 1 Tables 1.1 to 1.3 for details). Other cost determinants examined have been staff mix, health care quality, inflation, and economies of scope. The ability to include resource use variables is limited by the problem of heterogeneity within resource categories – for example, the number of equipment cannot be summarised in a single index due to the variety of items within any health facility. This is similar for other resources, such as drugs, staff and materials. For resource prices, on the other hand, an index can be put together that summarises price differences between health facilities (cross-section or time-series). The important variables to include vary according to the context of the study.

Functional form

The next important aspect of model specification is the functional form. Alternatives include ordinary least squares, logit/probit, or a survival model such as the Cox model. The model chosen depends on the nature of the dependent and independent variables, the distributions, and expected relationships. Final models are built by retaining in the model the statistically significant variables, and may also include non-significant variables that are considered important for the appropriate specification of the model. Alternatively, the exclusion of variables may be controlled by the software package using step-wise regression, although this method gives the analyst less control over which variables are retained or excluded. The final model is tested for heteroskedasticity (unequal variance for different values of dependent variable), omitted variable bias, and multicollinearity (correlation between independent variables) using standard statistical tests such as the F test and scatter plots. Also, in cluster randomisation design, if the variance of the different clusters are very different, the regression model must take this into account, otherwise standard errors are underestimated. In some cases, a transformation of the data is justified. For example, skewed cost data justifies a log or log log transformation in order to meet the distributional assumptions of the model (Coyle 1999). Also, the relationship between dependent and independent variables may not be linear, and square, square root, inverse, cubic or log terms may be added. This

can be examined in advance by fitting a curve, and observing whether the terms significantly improve on the linear fit.

Interpretation of results

The parameter estimates from the regression model need careful interpretation.

1. The intercept term. The coefficient of the intercept term gives the expected cost for someone who has the benchmark value ('0') for all variables. In the log cost model, it is also used for calculating the change in cost when one of the significant parameters changes value (see below).
2. The coefficients. These are the deterministic components of the regression equation, and are known as 'partial slope coefficients', as they indicate the impact on the dependent variable of a change in the independent variable, holding all other independent variables constant. They are the estimators of the "true" (population) coefficients. Given the assumptions of the classical multiple regression model, the OLS estimators are unbiased and have minimum variance (BLUE property). Their sign, size and precision with which they are estimated are all important for judging whether their covariates should remain in the equation. When costs are log transformed, the coefficients (B) represent percentage effects on cost, which have generalisable uses in predicting costs.
3. Standard errors. These are used to establish confidence intervals for the true parameter values. However, care should be taken in interpreting standard errors and statistical tests.
4. The error term. The error term from the equation is an estimator of the population error term. As the relationship in the equation is not deterministic, some variable in the equation must account for this. The error term captures measurement error as well as specification error. When the error term is not homoskedastic (equal variance) or not normally distributed, other functional forms, such as Maximum Likelihood Estimator are used.
5. R^2 . This is called the 'coefficient of determination' or 'goodness of fit'. In regression analysis, it is called the 'coefficient of multiple correlation'. It equals the regression sum of squares over the total sum of squares. Therefore $1 - R^2$ represents the

unexplained variation in the dependent variable. The adjusted R^2 (R^{2^*})²⁵ should be used when comparing different models (with different numbers of independent variables). This is because R^{2^*} removes the impact of degrees of freedom and gives a quantity that is more comparable than R^2 over models involving different numbers of parameters. Unlike R^2 , R^{2^*} need not always increase as variables are added to the model, and tends to stabilise around an upper limit as variables are added (Rawlings 1988). However, the F test is considered to be a better test of the model's strength than R^2 , because it has a distribution, as opposed to R^2 which is an index.

3.3.2 Data envelopment analysis

Introduction

Data envelopment analysis (DEA) is a mathematical programming technique, developed by Charnes et al (1978), following initial development by Farrel (1957). Therefore, it is a more recently developed and tested concept than regression analysis. Although a comprehensive literature review and discussion of issues was carried out by Broomberg (1997), the main elements are discussed here.

DEA combines a set of multiple input and output measurements in a non-arbitrary and non-subjective fashion to estimate technical efficiency. It 'envelops' the data with a non-parametric²⁶ production frontier, using the Pareto Efficiency criterion. In terms of the input criterion, a 'production unit'²⁷ is efficient if it is not possible to decrease any input without an increase in any other input and without a decrease in any output. In terms of the output criterion, a production unit is efficient if it is not possible to decrease any output without a decrease in any other output and without an increase in any input (Broomberg 1997). Therefore, DEA not only simultaneously accommodates multiple outputs and inputs, but it also identifies actual or potential inefficiencies in a manner more consistent with economic theory than econometric regression techniques (Sherman 1994). Earlier studies focussed on inputs in terms of physical quantities (and thus

²⁵ Adjusted $R^2 = 1 - (1 - R^2)(n-1/n-k)$. Adjusted R^2 will increase with the addition of further variables so long as the t value of those variables is greater than 1.

²⁶ This means that it does not presuppose the functional form of the technology.

²⁷ The basic unit of analysis in DEA is the 'production unit' and can be an entire hospital or health care agency, or sub-units of these, such as a ward or outpatient department.

technical efficiency); however, later studies have included costs as independent variables, thus giving a measure of economic efficiency.

The technical efficiency score

DEA evaluates the technical efficiency of a 'production unit' relative to other production units in a given sample by calculating a relative technical efficiency (TE) score for each production unit. The most efficient production unit(s) are given a TE score of 1.0, which corresponds to the assumed production possibility frontier (PPF). Thus the proportion of providers operating on the production possibility frontier can be estimated. The TE score is defined as the ratio of the total weighted production units' output to total weighted input. The computation of input weights is based on the maximisation of the TE for each production unit, subject to some constraints on the selection of weights. The technical efficiency of individual observation therefore is estimated to reflect the radial distance from the directly estimated production frontier (Banker et al 1986). The data indicate the reduction in resource inputs possible for inefficient units (at constant output), or similarly the increase in outputs possible (at constant resource use), assuming the production technology can be changed (Broomberg 1997).

The choice of input(s) and output(s) depend on the health care setting and study question. For example, the importance of different resources depends on the type of health care being evaluated, whether it is labour- or capital-intensive. Appendix 1 Table 1.4 shows that DEA studies use a variety of inputs and outputs. Studies have often concluded that the results depend on which functional form is chosen, and under what assumptions the model is run. For example, Broomberg (1997) tested seven output models and three input models to compare the efficiency of profit and non-profit hospitals in South Africa, and concluded that the sensitivity of the model to detect inefficiency was reduced when more variables were specified. Also, assuming constant returns to scale instead of increasing returns to scale tends to decrease the TE score of small producing units relative to large producing units.

Choice of model output(s)

Health service use, such as outpatient visits and inpatient days, is the most commonly used type of output. Health status is rarely considered due to the stringent study design required to give robust results. Broomberg (1997) chose inpatient admissions instead of inpatient days as the output measure in his study, because he argued the former represent a true hospital output, and because production of long hospital stays should not, per se, be seen as a desirable result. However, DEA studies to date are not very advanced in measuring multiple outputs in comparing production units.

The most advanced specification of hospital output found in the literature is in the study by Grosskopf and Valdamis (1987), who distinguished between inpatient days by type of treatment (acute or intensive care), surgical cases, emergency room visits and outpatient visits. A later study by Grosskopf and Valdamis (1993) accounted for varying case-mix by adjusting each hospital's outputs by the hospital's corresponding case-mix index, which inflated or deflated the value of the outputs produced. Other studies have taken a much simpler approach to the specification of output. For example, Bates et al (1998) compared General Practitioner practices according to the number of patients treated under and over 65 years old. Other authors avoided the case-mix problem by only including in their data sets homogeneous groups of patient (Nunamaker 1983).

Choice of model input(s)

Appendix 1 Table 1.4 shows that a variety of inputs have been used in published studies, including different types of staff full-time equivalent (FTE), capital (represented by building size or numbers of beds), measures of cost (supply cost, staff cost, capital cost). Authors rarely state why they include some inputs but exclude others.

Model specification

The DEA model also requires that an assumption should be made about whether economies of scale exist or not. Some studies compared results under the assumptions of both constant and variable returns to scale. For example, Kooreman (1994) found that when size was not included in the input measure (i.e. assuming constant returns to scale) the proportion of efficient homes went from 20.5% to 50.0%. Broomberg (1997) also

found that the results were sensitive to this assumption (larger hospitals benefit when variable returns to scale assumed).

Other specification problems discussed in the literature include the distinction between inputs and outputs. For example, should quality of care and numbers of services (economies of scope) be included as an input or as an output? Broomberg (1997) included a quality of care measure as an output, and found that it changes the relative efficiency of some production units. A further criticism of DEA is that it assumes a causal relationship between inputs and outputs, but does not assess the extent or nature of that causality. For example, use of inpatient days instead of inpatient admissions benefits hospitals with a longer length of stay, whether it is beneficial or not. Finally, the production possibility frontier is defined by the most efficient provider(s) in the sample; however, they may themselves be technically inefficient. In conclusion, correct interpretation is an important element of conducting a DEA.

3.4 Comparison of methods and conclusions

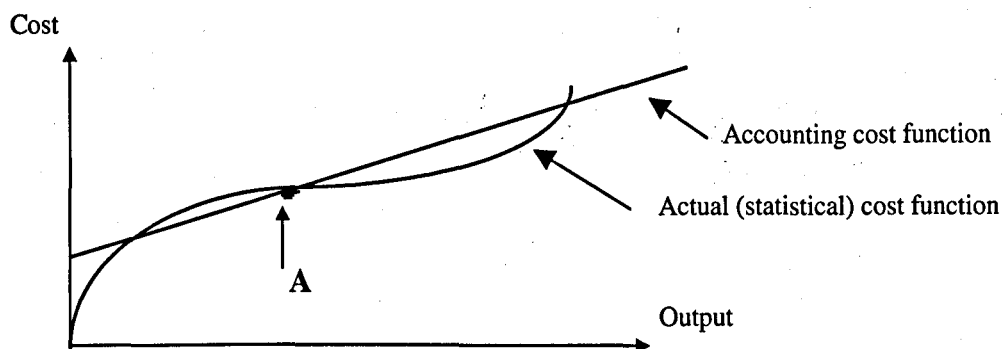
This chapter has discussed the strengths and weaknesses of a number of different indicators and methods for examining the causes of cost variation. These are now contrasted briefly in the light of their advantages and disadvantages.

The general features of accounting and statistical methods have already been presented. They have both been shown to include, or be capable of including, the three cost components of price, resource use and health service use. However, the way these are analysed varied between methods. Barnum and Kutzin (1993) made a useful distinction between them: accounting methods can be applied usefully to a single hospital, involving a labour-intensive, detailed examination of hospital accounts, staffing patterns and admissions, while statistical methods require observations of costs and service use for many hospitals.

So what are the underlying assumptions in these 'complementary' methods? Accounting studies, on the one hand, have an implicit underlying cost function represented by the sum of the products of the quantity of each input, multiplied by the respective price. This makes it rigid, and does not allow management or technical responses to changes

in input prices or quantities, and is therefore linear (marginal costs constant). Figure 3.1 illustrates that accounting studies generate a point estimate of total costs at the observed output (point A), but does not say much about what is likely to happen with changes in the price or quantity of an input.

Figure 3.1: Comparison of accounting and statistical cost functions



(source: Barnum and Kutzin 1993, page 115)

Statistical (or econometric) models, on the other hand, provide a more realistic depiction of how total costs change in response to differences in service mix, inputs, input prices, and scale of operations. It therefore allows for substitution between inputs as their relative prices and marginal productivity change. Statistical techniques are more comprehensive than ratios because they accommodate multiple outputs and inputs, resulting in greater confidence in the determination of causes of unit cost variation. However, as already discussed, the strength of conclusions from all types of cost analysis depends on the quality and nature of data, and whether appropriate transformations and functional forms are used. In this way, statistical techniques are more complex to perform and therefore without great care in analysis and interpretation there is a high chance of making erroneous conclusions.

A potentially important underlying weakness of regression analysis is the breakdown of its' implicit assumptions, such as profit-maximisation or cost-minimisation conditions, as described in Chapter 2. This is because the cost-output relationship is obscured, compared to what it would be under perfectly competitive conditions. This means that the source of financing of hospitals, and incentives to providers, may have important implications for how results can be interpreted. This has lead Lewin et al (1981) to conclude that insights provided by econometric techniques to guide performance improvement have been much more difficult in public sector organisations.

Appendix 1 Table 1.5 summarises characteristics of MRA and DEA approaches. DEA has the advantage of having few assumptions about the shape or form of the production and cost frontiers, as well as the distribution of the error terms. Therefore, heteroscedasticity and multicollinearity do not need to be identified or corrected for in DEA. Also, greater care is needed in MRA concerning the specification of the model: which variables to include and exclude, which variables have power terms, and whether values should be transformed into log values. DEA is a linear programming technique, and does not have these problems. Both techniques are vulnerable to small number of observations, although DEA can be used for fewer cases.

An advantage of DEA and some accounting measures is that they produce a single measure of efficiency, and can address efficiency issues directly instead of using average relationships. Consequently, DEA and accounting measures can pinpoint inefficient health care facilities from large samples, and indicate the extent of cost savings and efficiency gains from a shift to efficient production. As an aid to the interpretation of results from accounting techniques, simple statistical tests such as the Pearson correlation coefficient can be used to examine whether efficiency differences are strongly correlated with unit cost differences, while bearing in mind other possible causes of variation.

DEA also has several weaknesses. First, it is neither prescriptive in what to do about inefficiencies, nor does it provide absolute measures of inefficiency. This is because the measure of inefficiency is based on the most efficient health facility in the group, which may itself be inefficient. DEA does not identify the efficient production function, but it only suggests where costs can be saved without reducing output (Sherman 1984). The same criticism could also be levelled at accounting studies, such as staffing ratios, where a choice must be made about what ratio is desirable, or efficient (high ratios, though, might indicate low quality of care). Also, DEA assumes causal relationships between inputs and outputs, whereas the relationships may be stochastic rather than deterministic.

In analysing large data sets of unit costs, it is important to know to what extent different methods produce different results. If statistical cost functions do not differ significantly from accounting functions, then little will be gained from more complex and time-consuming analyses. Some studies have even compared MRA and DEA results on the same data set. For example, Banker et al (1986) compared their DEA results with data from a translog function, and found that only 48% of health centres were in agreement using the two methods (using a ranking of high, medium and low). A further 33% were in reasonable agreement, and 18% were in strong disagreement. Despite these apparent differences, the chi-squared test showed that the efficiency ratings were in broad agreement. Also, Huang and McLaughlin (1989) compared the results of DEA with the results of ratio and regression analyses, and found that the rankings of PHC programmes generally paralleled each other in all three techniques. Therefore, it is not entirely clear how consistent the conclusions are given by different cost analysis methods, and if different, why.

In the empirical literature searched, there were few studies comparing techniques to make clear conclusions concerning whether they complement each other, or whether they instead provide contradictory results. While such a comparison is important, this chapter has also focussed on the differences in aims of the alternative cost analysis methods. The methods in many instances provide different angles on the same data, thus not necessarily leading to conflicting conclusions. In conclusion, if there are sufficient data and research time, it is beneficial to an understanding of the data to conduct several of these analyses, to build the most comprehensive view of cost behaviour.

4 CAUSES OF COST VARIATION

4.1 Introduction

The previous chapter, Chapter 3, reviewed methods for analysing costs for the purpose of understanding cost behaviour. The conclusion was drawn that a variety of methods can contribute to a more complete understanding of cost behaviour than if methods are undertaken in isolation, as on the whole they provide complementary viewpoints. The aim of this chapter is to summarise the findings of empirical studies using the methods reviewed, with a focus on the causes of cost variation identified in Chapter 2. This chapter draws on a wide body of cost analysis studies, identified using literature search strategies described in Chapter 3. The empirical findings from the literature review are presented in terms of what could be said about cost behaviour - what factors do and do not explain cost - to give an indication of the weight of evidence, and therefore which factors are likely to require further study in this thesis.

Two approaches to cost analysis were found. One approach analyses costs at the micro level, where a health facility is studied in isolation, and the causes of cost variation examined in terms of which factors are most likely to influence or determine costs, such as throughput levels or staffing ratios. This approach uses accounting methods, as discussed in Chapter 3, and tends to focus on unit costs. The other approach analyses costs at the macro level, where groups of health facilities are compared, and causes of cost variation examined in terms of comparable indicators that are likely to explain these differences, such as economies of scale, case-mix, and input prices. This approach evaluates costs using both accounting and statistical methods (mainly the latter as documented in Appendix Tables 1.1 to 1.4), and can focus on unit, case or total costs as the dependent variable. Therefore this chapter identifies determinants of cost comprehensively by adopting the framework set out in the first chapter, taking into account causes of variation in health service use, resource use, and resource prices. In addition to these sources of cost variation, differences in costing methods, and the impact of uncertainty and measurement error are also examined.

4.2 Health service use

Health service use is an important determinant of total or aggregate cost, whether at the clinic, the ward, the hospital or the district level. Figure 1.1 in Chapter 1 showed calculations for costs at the individual patient level ('case cost') and at the hospital or programme level ('total cost'). The numbers of uses of health services are influenced by factors related to two actors: the user of the health service (the 'patient') and the supplier of the health service (the 'provider'). Each are reviewed in turn.

4.2.1 Patient factors

There is a considerable literature that has examined empirically the causes of variation in health service use, as determined by patient factors²⁸. A summary of those studies relating to the uptake for maternity services (both antenatal care and delivery) is presented in Table 4.1. A few factors have received most of the attention in the literature. These include the geographical accessibility of health services (mode of transport available and distance from health facility), the money cost of attending maternity services (money and time costs), socio-cultural factors (such as religious beliefs, permission from family members), and education status or general awareness of modern health services. Other factors studied include: whether the woman has had previous contact with health services; the existence of bad weather patterns that may make it impossible to travel (Voorhoeve et al 1984); services are viewed with suspicion (Bamisaie et al 1986); services are seen as upwardly mobile (Sargent 1985, Marshall 1985); alternative health care such as traditional medicine is available; and local beliefs about medical care. Roos and Roos (1982) and Wennberg (1985) also found that intervention rates were highly dependent on socio-economic characteristics of the patient. While many studies examined a variety of factors preventing uptake for maternity services, no comprehensive checklist of these factors was found in the literature.

In addition to studies focussing on one particular country or location, there are several review studies focussing on specific issues. For example, Thaddeus and Maine (1994) developed a conceptual framework for understanding why women who need care during pregnancy are delayed. Their "Three stages of delay model" model consisted of:

²⁸ Due to the relatively rich literature in health service use determinants for maternity care, only this literature is reviewed in this section.

1. *Delay in deciding to seek care on the part of the individual, family, or both.* This occurs for many of the reasons listed in Table 4.1, such as distance, cost, perceived quality of care, etc.
2. *Delay in reaching an adequate health care facility.* This occurs due mainly to poor road conditions, transport unavailability or cost.
3. *Delay in receiving adequate care at the facility.* This occurs due to poor referral system, and shortage of supplies, equipment and trained personnel. This has important feedback on the stage 1 delay for whether the woman is likely to seek treatment in the future, if she or her friends received poor quality care in the past (see section 4.2.2).

This is a useful model not only in explaining why women do not attend health services, in order to evaluate the cost differences between pregnant women, but it also informs policy makers and hospital managers about the most urgent changes required to improve attendance rates. A second review study examined the determinants of compliance with iron supplementation (Galloway et al 1994). Reasons for non-compliance were divided into three principal causes:

1. *Patient factors.* These included the patient misunderstanding instructions, adverse side effects, frustration about the frequency and number of pills taken, fear of having big babies, personal problems, nausea, and lack of attendance at health facilities to have anaemia diagnosed.
2. *Service delivery factors.* These included poor provider-use dynamics, lack of supplies, access, training and motivation of health care professionals (see next section).
3. *Programme support factors.* These included a lack of commitment and financial support, either from higher levels of government or international support.

These two studies are evidence that frameworks have been developed to study health service use, although they refer to specific health care interventions and thus cannot be applied without adaptation to any form of health service. In addition to the information on factors presented in Table 4.1, there are other factors that have received attention in the literature. A determinant of uptake rarely mentioned in the literature reviewed is the risk status and morbidity of women or their babies. For multigravidae, adverse outcomes

in previous pregnancies may also lead to greater numbers of visits as well as higher caesarean section rates (McCaw-Bins 1995). For example, previous CS is likely to require another CS; and previous spontaneous abortions may alert the provider to potential problems, thus causing more visits or inpatient stay. Also, babies with certain characteristics, such as low birth weight, congenital malformation, low Apgar score, etc, are more likely to receive special attention, if the facilities are available (Samson 1991, Khoshnood et al 1996). However, diagnostic-related groups have been shown to have limited relationship with cost, and thus are not deemed to be highly accurate for budget setting purposes (Bostrom and Mitchell 1991, Voss et al 1994, Khoshnood et al 1996).

In conclusion, a wide range of patient factors potentially responsible for uptake of maternity services have been found in the literature, and this review provides a useful starting point for the analysis in this thesis. However, the relevance of each factor is examined later in the context of the thesis, to allow focus on the most important factors.

4.2.2 Provider factors

There are also several factors related to the provider that influence uptake of services, some of which were mentioned earlier (Thaddeus and Maine 1994, Galloway et 1994). Also, some provider factors overlap with patient factors, such as geographical and financial accessibility. Less literature was found on provider factors that influence uptake of maternity health services compared to patient factors, especially in developing countries. Other factors that may influence a provider's incentive to treat or refer patients, such as the impact of financial incentives on practice, have received considerable attention, although the evidence for supplier-induced demand is mixed²⁹. Physician discretion and the presence of uncertainty in clinical decision making have been cited as causes of wide small area variation found (Wennberg 1984). This has been called 'practice style' - the concept that it is the physicians set of beliefs about the efficacy of particular forms of care - although there no objective means of measuring it was found (Folland et al 1994). Wennberg and Fowler (1977) argued that practice style differences can be concluded when all other possible causes of small area variation are ruled out³⁰. For example, both Postma et al (1993) and Rhodes et al (1997) found

²⁹ However, because the use of fees is limited in the study countries for this thesis, a review is not presented here.

³⁰ These studies do not examine maternity care specifically, but their conclusions remain valid for it.

variations in average length of stay when an identical treatment was implemented in similar populations in several countries simultaneously.

Another provider attribute, quality of care and its' impact on health service use, appears to have received limited attention until recently. However, few of the studies discussed in Chapter 3 on how to measure or represent 'quality' went as far as drawing quantitative links with health service use or cost (Gilson 1992, Pepperall 1995, Broomberg 1997).

The compliance of the provider with current guidelines is a potentially important determinant of health service use of pregnant women. However, if women do not attend health services when they are supposed to, the causes should be distinguished: was it because women were not encouraged to attend, women could not attend, or another cause. Provider compliance with these guidelines depends on several factors, including their own education and training, the presence of equipment, trained staff and materials to carry out appropriate diagnostic tests, and the presence of monitoring procedures to make sure providers are compliant. However, due to differing medical viewpoints, risk assessment is subjective, and treatment and referral depends to a large degree on the risk aversity of the provider.

4.3 Resource use

The other component of case or total cost is unit cost, one component of which – resource use – is examined in this section. Again, as in the case of health service use, rarely do studies make statements about the significance (either statistical or economic) of the variations identified. Therefore, it is not clear to the reader whether the differences being investigated are important differences³¹.

This section is divided into seven sub-sections, based on the findings in Chapter 2 on potential causes of resource use variation, and uses the same literature as that identified in Chapter 3 but with a focus on empirical findings.

³¹ First, differences may not be provable in a statistical sense; second, even if a difference is proved statistically, the money difference may not be large enough to lead to different decisions about the way health care is provided.

4.3.1 X-efficiency

While a number of studies identified in the literature have shown evidence of inefficient use of resources, very few accounting studies have tested whether there exists an empirical link between inefficiency and unit cost (i.e. are unit costs higher *because of* inefficiency? And if so, *how much* higher?). One study, Robertson et al (1991), did consider this link, and found that differences in the number of services provided per hour of work partly explained differences in unit costs between Ministry of Health and social security primary health care services in Ecuador. However, other studies that identified inefficiency did not evaluate its' impact on unit cost. For example, Daly et al (1998) found that wasted drugs accounted for 54% of the total drug cost for STD treatment in Malawi, but no calculations were presented to show what unit cost would be if drugs had not been wasted. Similarly, Lewis et al (1991) found that only 12% of contracted physician time could be accounted for by patient-care activities, but the impact on unit costs was not examined, nor were they compared with unit costs of more 'efficient' health facilities. Bryant and Essomba (1995) found that 73% of staff time was unproductive, but unit costs were not measured. There are many other such examples where authors have not provided adequate evidence for the link between efficiency and cost, including Mills et al (1989) in Malawi, Banta (1985) in China, Waddington et al (1989) in Africa, and Lewis et al (1996) in the Dominican Republic.

As discussed in Chapter 3, DEA does not say anything about what the unit cost could be under absolute efficiency, although the technical efficiency score can be compared with unit costs across a sample of health facilities. For example, Valdmanis (1990) correlated the efficiency measures with costs per adjusted patient day using the partial Pearson coefficient, and found that the more technically efficient hospitals were more likely to have lower costs, *ceteris paribus*. Other DEA studies drew conclusions about the characteristics of production units most likely to have a high TE ratio. For example, Ozcan and Luke (1993) concluded that the population size served by the health facility determined efficiency, due to differences in occupancy rates. This raises a possible problem in the interpretation of DEA results: that the TE score may contain types of inefficiency that are not defined as 'X-inefficiency', such as low occupancy rates.

Regression studies, on the other hand, have rarely looked at the impact of X-efficiency on unit costs. This is largely because regression analysis is based on the assumption that production units are already operating on their production possibility frontier. However, differences in productivity have been suggested by studies that examine the impact of ownership on unit costs. The evidence from this literature is mixed, as unit costs have been found to be both higher and lower in public health facilities when compared with private for-profit (PFP) or private not-for-profit (PNFP) health facilities. For example, Beecham et al (1993) found that PFP and PNFP mental health care providers had lower average costs than public providers, and Salavitarab (1982) found PFP had higher average costs than PNFP hospitals, and PNFP hospitals had higher average costs than public hospitals. On the other hand, Bays (1980), Pauly (1978) and Cowing and Holtman (1983) found that PFP hospitals had lower average costs than PNFP. In none of these studies was there adequate consideration of *why* unit costs differed, and whether it was due to different levels of X-efficiency, or for other reasons.

4.3.2 Returns to the variable factor

The impact of under-utilised health services has been quoted widely in the literature as having a significant impact on unit costs (for example, WHO 1979). However, while programme managers and researchers are ready to make these conclusions, empirical evidence is limited from the literature reviewed. For example, Berman (1986) concluded that differences in utilisation rates and programme management 'probably' accounted for most of the variation in unit costs, although the exact proportion was not determined. Robertson et al (1984 and 1992) concluded that the EPI programme in The Gambia enjoyed lower average cost as volume rose, due to the substantial proportion of fixed costs. The Data for Decision Making (DDM 1997a) project in Egypt used a combination of ratios to judge hospital performance, and causes of unit cost variation, which ranged from 15 to 82 Egyptian pounds per inpatient day in the study hospital. Low occupancy rates and high number of medical staff per bed in high cost wards were the two main factors explaining cost per day differences. These conclusions were made on the basis of 2-way tabulations of these data, thus ignoring other cost impacts associated with increasing hospital or ward size. Many other studies have presented minimal data sets on the basis of which they have drawn conclusions about the impact of utilisation levels on unit costs (Ugalde 1984, Berman et al 1989a, Berman et al 1989b, Lewis et al 1991, Ehreth et al 1993, Janowitz 1992, Jeffers and Siebert 1974). Also, some authors did not

distinguish clearly between returns to the variable factor and economies of scale (see Chapter 2).

None of the econometric studies found directly addressed the impact of unused capacity on unit costs. However, the important issue of planning for demand uncertainty has gained some attention in the regression literature reviewed, as demand uncertainty is responsible for both lower and higher occupancy rates than those planned. For example, Friedman and Pauly (1981) studied the impact of stochastic demand on the service level and average costs of hospitals, and found average costs highly sensitive to the utilisation rate (expected + actual output). Results from other studies indicate that demand uncertainty accounts for some of the observed excess capacity of hospitals, and that it leads to decreasing costs when hospital utilisation changes (Lave and Lave 1970, Joseph and Folland 1972). Gaynor and Anderson (1995) found using regression analysis that hospital costs would reduce 0.34% if bed capacity was reduced by 1% in the USA; also they concluded there would be savings of US\$2.19 million (1992 prices) from increasing occupancy rates from 65% (1992) to previous rates of 76% in 1980.

Studies using DEA also did not make specific conclusions about returns to the variable factor, although some studies concluded that they explained why some health facilities were operating at below 100% efficiency. For example, Banker et al (1986) found that hospitals with high capacity utilisation (>82.6%) were more likely to be technically efficient, although hospitals with low capacity utilisation (<71.3%) could also be technically efficient. Also they found that no hospitals with high capacity utilisation were in the lowest technical efficiency range. This finding suggests that low occupancy is picked up in the TE ratio.

In conclusion, the link between occupancy rate or capacity use and unit cost is unambiguous, and potentially an important determinant of unit cost if the fixed cost element of unit cost is high. Therefore the link with health service use (section 4.2) should be recognised. Returns to the variable factor are relatively easy to diagnose using simple methods, such as recalculating average cost based on different capacity use assumptions.

4.3.3 Economies of scale

Whether economies of scale exist, and what the optimal size of health facilities or health care programmes (e.g. immunisation) are, have been the subject of a large number of cost studies. However, there is considerably mixed evidence in the literature regarding economies of scale. A review carried out by the Nuffield Institute for Health concluded that economies of scale are more likely to exist in acute hospitals with 100-200 beds, whereas diseconomies of scale are likely to exist in hospitals with more than 300-600 beds (NIH 1996). This lack of definitive conclusion is supported by the studies presented in Appendix 1 Tables 1 to 4. Cowling et al (1983) have also shown that in small hospitals (less than 100 beds) there is little evidence of significant economies of scale.

Using accounting techniques, scatter plots have been used for assessing the general relationship between size and average cost, with generally positive findings of economies of scale (Robertson et al 1992, Brenzel and Claquin 1994, Jian et al 1998, Flessa 1998). Gilson (1992) concluded that economies of scale probably existed for immunisation services, but not for curative or delivery care. However, these accounting studies suffer from the confounding effect of other variables that determine average costs, and that must be allowed for. Also, many of these studies had a small sample, which reduces the statistical power of cross-facility comparisons.

4.3.4 Economies of scope

The impact of the number of services available or used by patients on unit costs has been examined in econometric studies (see Appendix 1 Tables 1.1 to 1.3). Again, there is very mixed evidence of their existence. Cowling and Holtman (1983), Hornbrook and Monheit (1985), Custer and Willke (1991) and Bitran-Dicowsky and Dunlop (1993) all found significant economies of scope, while Barnum and Kutzin (1993) and Scott and Parkin (1995) did not find strong evidence. Therefore, the regression analysis literature reviewed is inconclusive about whether or not economies of scope exist at a general level. Again, economies of scope are context-specific.

The only accounting study found that examined the existence of economies of scope was by Robertson et al (1991), which compared the unit costs of health facilities in Ecuador with and without dental services (as an indicator of the number of facilities

provided). Using visual examination, they found a negative correlation between number of health services and unit costs, although they admitted that this could have been confounded by differences in staff productivity. No studies in the review using data envelopment analysis have examined in detail whether economies of scope exist, except Valdmanis (1990) who found that overall technical efficiency is inversely related to the number of services available (although this association was not strong). It should be noted, however, that most cost analysis studies compared homogeneous groups of health facilities, and therefore the question of cost variation being caused by economies of scope did not arise. This suggests it is important to compare the homogeneity of the health facilities with respect to service availability before including a 'scope' variable.

4.3.5 Input mix

The influence of input mix on unit cost has not been examined much in the reviewed articles, with only few examples found. Input mix can be defined either by the percentage contribution of different resource ingredients to cost (in monetary units) which only gives a measure of relative intensity, or the observed resource use measured in physical quantities (which gives a truer measure of 'intensity' as compared to an average value defined for the purpose of measuring intensity). Note that resource use intensity is likely to be highly dependent on prices and the elasticity of substitution (see section 4.4). Using regression analysis Zuckerman et al (1994) found that the intensity of resource use explained some of the unit cost differences between hospitals in the USA, with hospital inefficiency increasing with the intensity of input use. Their conclusions took into account that the frontier estimates may not have incorporated other outputs or quality levels that increased intensity of resource use give rise to.

Mills (1990) argued that differences in input mix should be expected where the level and location of hospitals differ. For example, specialised hospitals may have a lower share of wages due to more sophisticated buildings or due to more expenditure on support services and utilities. Also, the proportion of labour cost may also be low in developing countries due to lack of skilled manpower (leading to substitution of other inputs). However, a lower share of wages does not necessarily indicate lower staff intensity, as other items may be relatively more expensive, such as when developing countries face world prices for drugs and equipment but local prices for non-traded goods. Prices may or may not have a strong influence on choice of input mix, but will in

any case influence the relative shares of different types of input, assuming inputs can substitute for each other.

Some studies were found that used regression analysis to determine optimal levels of input mix. For example, Wan et al (1987) used regression analysis to determine the optimal staff mix (numbers of residents per dentist) to minimise unit costs. Wouters (1993) found that the staff mix of health centres in Nigeria critically determined unit costs. Finally, prescribing patterns (Creese, 1984) and vaccines use (Berman, 1991) have also been found to change input mix, and thus unit cost. Teaching status has also been examined with respect to how it influences the quality of care and unit costs, although the evidence is ambiguous. Soderlund et al (1995) found that teaching status and higher labour input did not influence costs, whereas many regression studies have found higher costs in teaching hospitals (e.g. Cowper 1997).

4.3.6 Quality of care

Few studies found in the literature search examined the influence of quality of care on unit costs. Despite this, some form of quality indicator was often included. Increasing quality has been found in some studies to increase unit costs, although increase in quality may lead to efficiency gains thus having the opposite effect on unit costs (Gilson 1992). The cause of unit cost increases can be both increases in resource use and resource prices (section 4.4), especially in private hospitals where better quality staff may be attracted with higher salaries. Berry (1973) found that quality-enhanced service hospitals cost 16% more per inpatient day than basic service hospitals in the USA. Gilson (1992) found an association between structural quality and total cost. On the other hand, she did not find significant associations between average cost and quality, or average cost and health service utilisation.

The relationship between quality of care and other economic variables has also been examined. For example, Cohen (1970) found that optimal hospital size increased with increases in the quality of care provided, thus suggesting that it may be difficult to disentangle quality and scale effects when estimating hospital cost functions. Baron (1978) found that the quality of obstetric units increased with size. Broomberg (1997) and Kooreman (1994) both found that when a structural quality index was included in the output measure it affected the size of inefficiency observed. Most regression analysis

and DEA studies, however, have made the simplifying assumption that quality was identical between health facilities (Sherman 1984, Bannick et al 1995, Valdmanis 1990). In conclusion, the joint problems of defining and measuring quality of care makes it difficult to capture quality aspects as a determinant of cost, despite its' potential importance as a determinant of unit cost.

4.3.7 Case-mix

The impact of case-mix on unit cost, resource use and length of stay has been examined by numerous studies using regression analysis, which have generally found a highly significant impact of case-mix on cost (see Appendix 1 Tables 1 to 3). The expected impact is unambiguous, as more severely ill patients will stay longer (except when they die) as well as require more resources per day. Also, more severe cases may require more advanced equipment or better quality staff, with higher prices. Feldstein (1967) found that case-mix differences explained 27.5% of cost per case differences between a sample of hospitals in the USA, and Evans (1971) explained 51.4% of cost per inpatient day differences between hospitals using case-mix measures. Salhever (1972) found that changes in case-mix over time had a greater impact on hospital cost inflation than supply factors. Lave et al (1972) found that a high proportion of difficult cases led to higher than average costs.

More recently, Soderlund et al (1995) found that case-mix differences accounted for approximately 77% of the differences in cost per finished consultant episode between providers, from nine acute-care NHS hospitals in the UK. Using 10 case-mix variables Watts and Klastorin (1980) found that case-mix and average cost were positively correlated, explaining as much as 70% of unit cost variation between hospitals. Other studies have compared case-mix and resource use, such as Bostrom and Mitchell (1991) who found that nursing input varied enormously between four levels of DRG rating. Also, McCrone et al (1998) found several patient factors (such as age, place of birth, suicide risk) had a significant impact on the case costs of mental health care services; however, only 31.5% of cost variation was explained. Many other socio-demographic characteristics were found not to have influence on costs.

Non-significant results of relationships between case-mix and costs have also been found. For example, Butler et al (1995) classified patients by stage of detection of

cancer, and still found an enormous inter-patient cost variation within the same stage, although cost differences between stages also emerged. In conclusion, the link between case-mix and costs depends not only on whether the case-mix measure is indicative of cost, but also on the range of severity within a single category. Therefore, although confounding effects should be sought, case-mix is a potentially important source of cost variation between health facilities that treat different profiles of patients.

4.4 Resource price

4.4.1 Absolute price

Butler (1995) argued that when input prices are the same for all hospitals in a costing study, then prices cannot possibly be a source of cost variation, and so can be ignored. However, prices often vary within as well as between countries, and therefore prices cannot necessarily be assumed to be the same. For example, staff salaries may be greater at referral or urban health facilities than at primary care or rural ones; the price of other materials and equipment depends on whether bulk purchases are made.

Despite the direct effect of price differences on unit costs, and the ease of identifying this effect using sensitivity analysis, surprisingly few studies were found in the review that evaluated the extent to which price differences cause unit cost differences. One study, Pauly (1978), found that differences in input prices between hospitals explained only 6% of cost variation. Cromwell et al (1987) found that part of the cost per admission differences (between 13% and 61%) between urban and rural hospitals was due to differences in wages between these locations, accounting for up to 33% of the variation. The impact of inflation on unit costs over time was also examined by Jeffers and Siebert (1974), who found that rising factor input prices accounted for 80% of the rise in average cost in a single hospital between 1960 and 1969.

At the global level, Barnum and Kutzin found a positive correlation between average (health care) costs and GNP per capita: "...the richer countries (Belize, St. Lucia, Turkey, Jamaica) have the highest unit costs, and the poorest nations (Malawi, Niger), have the lowest unit costs" (Barnum and Kutzin 1993, page 19). Also, in a multi-country costing study of stroke care, Grieve (1999) found the costs per patient were higher in Western European countries (UK, France, Denmark) than Eastern European

countries (Lithuania, Poland). These findings are hardly surprising since personnel usually make up the largest share of cost, and wage rates are highly correlated with per capita income. On the other hand, countries with low prices may also have more intensive use of resources, thus obscuring the relationship between the price levels and average costs. In conclusion, differences in price levels of health sector resources are an important determinant of unit cost, and are likely to explain unit cost differences, particularly over time and between countries with different income levels.

4.4.2 Relative price

Limited empirical work was found in the review on the relationship between relative prices and input mix in the health sector, and whether input substitution takes place. The impact of differences in relative prices between settings is more difficult to model, as input substitution must be taken into account, thus changing the input mix (discussed in section 4.2.5). One example, Grieve (1999), tabulated staff mix with relative prices of different categories of staff (nurse and doctors) in six European countries to allow preliminary conclusions that a low relative price of one category of staff does not necessarily lead to a higher input share. Four studies were found that included price variables as independent variables in econometric equations (Baron 1974, Baron 1978, Pauly 1978, Conrad and Strauss 1983, Cowing and Holtman 1983). The mechanism by which relative prices influenced the input mix was not entirely clear from the results of these studies, and therefore the substitutability of inputs was not known. However, one of these (Conrad and Strauss 1983) found that nursing and ancillary services were complementary to capital items, while general services were substitutes for capital items.

4.5 Costing methods

The impact of differences in costing methods, such as cost inclusion criteria or cost measurement techniques, on unit costs is potentially a highly significant cause of unit cost variation between settings (Janowitz 1992, Guyatt and Tanner 1996, Schulman et al 1996). However, differences in costing methods were cited surprisingly little in the studies reviewed as a possible source of unit cost variation. This was partly because in many of these the costing methods were standardised to make estimates comparable, or they were assumed not to be a cause of cost variation. However, economic evaluations of multi-centre and multi-national trials are becoming increasingly common, where

different costing methods are used across centres. For example, Coast et al (2000) used different sources of resource use and valuation data to cost five hospital-at-home schemes, thus reducing comparability. Jonsson and Weinstein (1997) described the differences in costing methods necessary in an economic evaluation taking place in 14 countries: in the USA a cost-to-charge ratio was applied to hospital charges; in Canada unit costs were estimated using accounts and general cost allocation methods; in European countries, costs were assembled from a variety of sources, including published studies, accounts, and tariffs.

In cost analysis studies that used secondary data sources, the potential sources of cost variation are greater; however, few analysts in the studies reviewed considered in detail the differences in costing methodologies. In their cost comparisons, Postma et al (1993) admitted that some unit cost estimates used bills instead of costs, and may have included different costs. Grosskopf and Valdamis (1987) and Rosenman et al (1997) both found that costing methods and accounting methods varied considerably across health providers, such as between private and public organisations, or between health maintenance organisations. These differences included the definition of items, and calculation of net assets. However, rarely did study authors comment on whether the same information was available in all participating facilities, and what was done when data were missing.

Subsequently, it was mainly the review studies, such as Barnum and Kutzin (1993) and Janowitz and Bratt (1992) that argued that the costing methods may account for a part of unit cost variation. For example, Barnum and Kutzin distinguished broadly between step-down analyses and 'other' accounting studies in the literature. They concluded that the latter type contained fewer details and insights than do the former, as the step-down analyses enable scrutiny of the hospital production process to enable the best assignment of costs to the outputs to which they are related. Also, authors constructing cost-effectiveness league tables encourage standardisation of costing methods to improve comparability of cost-effectiveness ratios (Gerard 1992).

Janowitz and Bratt (1992) suggested that one of the major obstacles to cost comparability in cost studies of family planning services was the lack of standard

approach or format for gathering cost data. They cited several types of methodological issues that contribute to the difficulty of comparing estimates, although they were not evaluated empirically in their study.

1. Exclusion of some costs from estimates,
2. Varying methodologies for allocating time and overhead,
3. Inconsistent treatment of capital costs,
4. Classification of training as a capital or a recurrent cost,
5. Treatment of “free” components, and
6. Differences in exchange rates.

The importance of point 5, the treatment of free components, was raised by the Partnership for Child Development project (PCD 1998), that showed that economic cost exceeded financial cost by 44%, after including the time cost of voluntary labour and money cost of donated drugs in the former. This raises the issue of ‘opportunity’ cost, where the prices paid for resources do not necessarily reflect market rates (as market prices are assumed to equal opportunity cost – the ‘true’ cost to society of using a resource) (Curry and Weiss 1993). While some attempts have been made to identify opportunity cost (the ‘next best’ use of the a resource - Little and Mirrlees 1982), these techniques may not be entirely appropriate for the health sector, whose aim is maximisation of health, and not maximisation of national income or foreign exchange earnings (which are the focus of the development project appraisal literature). Therefore, in conducting costing studies in the health sector the analyst is instead recommended to use financial price (unless opportunity cost is available), and provide some range where opportunity cost is likely to fall in a sensitivity analysis (Drummond et al 1997).

In conclusion, costing methods need to be scrutinised in all cost comparison studies, even in primary cost studies that use a standardised method in different health facilities, due to differences in interpretation of instructions by researchers and differences in the availability of data.

4.6 Uncertainty

Uncertainty potentially plays an important part in understanding causes of cost variation. Uncertainty exists in different forms, including: insufficient observations on a parameter or missing data, inaccuracies in recording systems or outdated price data, uncertainty in

cost apportionment from overhead to health care departments, valuation uncertainty, or uncertainty in generalising data across settings (Briggs et al 1994, Manning et al 1996). Uncertainty can either lead to biased estimates of cost, or wider confidence intervals in cost. However, for uncertainty to be a cause of cost variation, at least one of these must be different between settings. In making cross-setting comparisons of cost, differences in uncertainty were rarely cited as a source of cost variation.

4.7 Implications for cost prediction methods

The review of the cost analysis literature in this chapter found that few studies identified were successful in explaining cost variation comprehensively, nor in using the full range of cost analysis methods. Despite the general poor quality or lack of comprehensiveness of cost analysis studies reviewed, the literature reviews in Chapters 2-4 have been useful in identifying several useful frameworks. The first framework clarified the relationships between important components of cost, namely health service use, resource use and prices (see Box 1.1 and Figure 1.1). The second framework clarified the alternative cost analysis methods available for the analyst, and what the purpose, strengths and weaknesses of each were. The third framework identified and separated various factors that were hypothesised to cause costs to vary, using economic theory. These frameworks, and the literature reviews that have served to inform these frameworks, will be used to identify alternative approaches to cost prediction, as well as be used to judge or explain the successes and failures of these cost prediction approaches.

The main implication for cost prediction methods of the cost analysis framework is that cost predictions are most likely to be accurate when all components of cost are taken into account in a cost prediction. To understand causes of variation in these cost components requires the application of cost analysis methods identified above. However, in the absence of detailed cost data to perform these analyses before a prediction, cost predictions are made with inadequate understanding of cost determinants in a setting. This no doubt would change over time, as more research is conducted into determinants of cost, and the performance of alternative cost prediction techniques is known in advance with more certainty. At this stage, therefore, alternative cost prediction methods should be identified and tested, to draw conclusions about their strengths and weaknesses. Five different cost prediction techniques, derived from the

cost analysis literature, are presented below, with examples from previous cost studies that have predicted costs.

1. In the absence of any local data and other techniques for cost prediction, it may be necessary to assume that the same level of costs exist across different settings. This method is termed the '**direct transfer method**'. All types of cost in Box 1.1 can be transferred in this way. If the settings are in different countries, the method for currency exchange must be decided between nominal exchange rates or some measure of purchasing power parity. This method does not take account of different patterns of baseline resource use and/or relative prices of inputs in different settings, which may be a disadvantage for cross-country predictions where differences are more likely to exist. Examples from the literature for transfer of health service use include Kinoshian and Eisenberg (1988) and Rodby et al (1996), who both used the health service use rates from a single RCT to model cost-effectiveness in other settings. Examples from the literature for transfer of unit cost include Politi et al (1995) who assumed average costs per inpatient day from a published study represented costs represented costs in all public hospitals in The Gambia. An increasingly used form of direct transfer has been the use of unit costs from one centre in a multi-centre trial in the other centres. For example, unit costs proxied by DRG rates were transferred directly from Sweden to four other Scandinavian countries in the Scandinavian Simvastatin Survival Study (Jonsson et al 1996). Also, Medicare DRG reimbursement rates in the USA were used for ten other countries in the GUSTO trial (Mark et al, 1995). Few examples of direct transfer of total costs were found in the literature. Those found include Broomberg et al (1996) who transferred the costs of a mass media campaign from the Dominican Republic to the rest of developing countries, at a cost of \$440,000 for a city-wide programme with similar levels of output. No adjustments were made for differences in income level across country. Also, Maine (1986) and Tinker and Koblinsky (1992) both used total health care costs of investments in infrastructure and recurrent expenses to estimate the cost-effectiveness of alternative Safe Motherhood options in developing countries (specifying three different levels of health system development proxied by per capita income).

2. If some local data are available on one or more of the cost components, and costs from the original study are disaggregated, then an adjusted transfer may be possible, using the technique of sensitivity analysis to substitute the local data into the cost calculation to produce a hybrid cost (i.e. one that contains both local and generalised data). Therefore, if cost determinants are known to vary between settings, such as determinants of resource use (case-mix, resource use intensity, returns to the variable factor, or staff productivity) or health service use, appropriate adjustments can be made. This method is termed the '**adjusted transfer method**'. In theory, this method should produce more accurate predictions than the direct transfer method, due to the use of local data in the calculation. In practice, it may involve (i) transferring health service use data, and applying local unit costs, (ii) using local health service use data and applying transferred unit costs, (iii) using key local prices or resource use in estimating unit costs. Examples in the literature include Edelson et al (1990) and Goldman et al (1991) who predicted total costs using drug prices from a survey of local pharmacies in conjunction with Medicare charges for inpatient care to estimate the local specific costs. Also, Walker et al (1991) predicted total costs using unit costs data from a single trial, and adjusting these for expected differences in staff and computer usage, as well as reducing compliance (and therefore health service use) rates. Simon (1986) predicted the costs of hospitalisation, by inflating unit costs from a previous year, and adding costs that had been excluded to reflect the viewpoint of their study. A study by Goodman et al (1999) predicted costs of insecticide spraying to reduce malaria morbidity in a range of countries, using a number of different data sources. Data sources included a review of the literature, programme budgets, price catalogues for internationally traded goods, and consultation with field staff to collect data or ensure assumptions were realistic. Adjustments to transferred data were made using local data to increase the accuracy of the predictions. As a final example, Menzin et al (1996) used the results of a RCT in the USA to estimate the total costs of rhDNase in the treatment of cystic fibrosis in four European countries. Health service utilisation data were transferred adjusting for local practice patterns – likelihood of hospitalization (consultation with experts) and associated mean length of stay (from case notes and consultation with experts). Unit costs were applied from each country, which were adjusted to be comparable due to differing costing methodologies (some details were provided).

3. A third technique uses knowledge of cost relationships that are relatively stable or constant across health care setting. For example, some studies (e.g. Knapp and Beacham 1993, Whynes and Walker 1995) have identified the most costly parts of interventions to generate a reduced-list costing. Likewise, a costing method can be derived from the recognition that some resources contribute the most to cost, and thus based on assumptions about the proportion can be scaled up to approximate total cost. The **'simplified staff costing method'** assumes that the cost relationships between staff cost and total cost is relatively stable. Therefore, average costs are predicted using local staffing cost data and throughput, which are 'scaled up' using data about proportion of staff cost to total costs in other settings. However, no studies were found in the literature search that predicted unit costs based on staff cost alone.

4. A fourth technique predicts the expected changes in the costs of current care due to a change in health care approach, using local data and assumptions about impacts. In this thesis, it is termed the **'incremental cost impact method'**. This approach considers the evidence from other settings as well as expert opinion about how the ingredients of care, the use of services and morbidity levels are altered under a new form of care, and then makes estimates of the impact on costs in the local context. The incremental cost impact method is different from the adjusted transfer method, in that prices and resource quantities are not transferred from other settings. Instead they are built from expectations of values in the local setting, based purely on local evidence and assumptions. One example of the incremental cost impact method was the **'Reproductive Health Care Costing Spreadsheet'** (Weissman et al 1999) which used a generalised framework to estimate the cost per woman of applying the W.H.O. Mother-Baby Package in Uganda based on local data, compared to the costs of current care, giving an incremental cost. Another example of the incremental cost impact method from the research literature is a study by Boulanger et al (1999) which compared actual treatment costs of childhood sicknesses with the hypothetical costs if the health provider had followed the Integrated Management of Childhood Illnesses (IMCI) in rural Kenya. Actual treatment costs were estimated by extracting treatment information from health cards. IMCI treatment costs were predicted by multiplying high and low dosage requirements by drug prices, thus giving a high and low cost estimate, and an incremental cost. This method requires detailed data on coverage rates, prevalence and

incidence of specified conditions, health sector infrastructure, referral patterns, and typical resource use and costs.

5. A fifth and final technique uses a regression model to identify cost determinants, which are then used to predict costs for another setting with a different set of parameters. It thus assumes that cost determinants are similar in different settings. This technique is called the '**regression method**'. In the regression literature (such as those studies provided in Appendix 1 Tables 1.1 to 1.3) few studies were found to go beyond the bounds of the data set and predict costs in different settings or populations, and compare predicted with observed costs. Non-monetary cost dependent variables have been modelled as well as monetary dependent variables. For example, Khooshnood et al (1996) predicted the length of stay in neonatal intensive units, and found that birth weight, survival, and total parental nutrition together explained 66% of the variability of length of stay between neonates. Also, Cowper et al (1997) found that clinical, demographic, hospital and regional characteristics only explained 16% of variation in length of stay between coronary artery bypass surgery patients in the USA. Of particular relevance for this thesis, there were a number of studies that predicted episode costs using regression analysis (see Appendix 1 Table 1.3). For example, Dudley et al (1993) compared the predictions of five statistical models with observed data, on the cost of coronary artery bypass graft surgery. They predicted mean cost for a hypothetical typical patient by inserting the median characteristics in the equation, and found that the models varied in terms of predictive accuracy.

5 CONTEXT AND METHODS

This chapter describes the World Health Organization (W.H.O.) antenatal care randomised controlled trial (which forms the context of the empirical work of this thesis), lists the empirical objectives, and describes methods of data collection and analysis.

5.1 The W.H.O. antenatal care trial

The W.H.O. recently evaluated the impact of an evidence-based programme of antenatal care (ANC) in four countries. In this trial, economic and quality of care components were planned as well as the clinical and health impact. This section describes important aspects of the trial briefly, but the reader is referred to Appendix 2 for a summary description of clinical component information, Appendix 3 for a description of economic evaluation methods (Mugford, Hutton and Fox-Rushby 1998), and to Lumbiganon et al (1998) for a fuller description of trial context and methods.

The hypothesis of the W.H.O. antenatal care trial was: "A new model of antenatal care which includes only those components shown to be effective in improving maternal, perinatal and neonatal outcomes, is more efficient than the traditional model with regard to specific maternal and perinatal endpoints, among singleton pregnancies, and is not more expensive" (WHO 1996, page 9).

Study design and sample size. This trial was designed to be a multicentre multi-country randomised controlled trial. Trial centres were in Argentina, Cuba, Saudi Arabia and Thailand³². The sample size needed from the four study sites was 19,087 subjects (Donner et al 1998). The trial randomisation design was based on health facilities rather than patients ('cluster' design). This was necessary to reduce the risk of treatment contamination, to encourage the participation of the women, and to facilitate logistic and administrative convenience in the implementation of the intervention.

³² These countries were chosen for two principal reasons: there was a minimum level of antenatal care in place to act as the comparison group; there was the basic infrastructure (research facilities and data systems) for high quality research.

The intervention: In each country at least six health facilities³³ provided the new antenatal programme, and at least six the current model of care. The new programme consisted of tests, clinical procedures and follow-up actions scientifically demonstrated to be effective in improving maternal and newborn outcomes, avoiding the use of technology not affordable in developing country settings. These interventions were distributed among four visits over the entire course of a low risk pregnancy. Appendix 2 Table 2.2 provides a summary of the contents of the new ANC programme.

Health outcomes: The effectiveness of the programmes was compared in terms of two primary outcomes: low birth weight and an index of maternal morbidity³⁴. In addition, several secondary outcomes and process outcomes (including perceived quality of care, satisfaction, and cost) were compared (see Appendix 2 Table 2.3).

Study sites: A description of study sites is provided in Appendix 2 Table 2.1. In Thailand, the trial took place in Khon Kaen province in north-east Thailand, where there are a total of 20 district hospitals (serving 193 health centres) of which 12 district hospitals participated in the ANC trial. There are also three central hospitals in Khon Kaen city itself that provide both routine and high risk care for pregnant women (a university hospital, a regional hospital, and a maternal and child health hospital). Nurse midwives are the main providers of antenatal care. Most ANC is provided in the district hospitals, and about 90% of women deliver their babies at the health care facility where they had their ANC. Caesarean section is available in most district hospitals. The ANC schedule follows the traditional 'Western' recommendations.

In Cuba, the trial took place in three municipalities in the capital, Havana city. All five policlinics in Old and Central Havana participated, and two policlinics (out of 5) in East Havana. 100% of deliveries take place in maternity hospitals. ANC is provided by general practitioners or obstetric specialists, complemented by a comprehensive system of social, medical and nutritional services. The amount and content of care is almost equivalent to the best ANC in developed countries.

³³ In Cuba and Saudi Arabia, policlinics; in Thailand, district hospitals; in Argentina, health centres & hospitals.

³⁴ The presence of at least one of the following: (a) pre-eclampsia or eclampsia during pregnancy or within 24 hours of delivery; (b) postpartum anaemia (haemoglobin <90 g/L); or (c) severe urinary tract infection/pyelonephritis, defined as an episode requiring antibiotic treatment and/or hospitalisation.

In addition to Cuba and Thailand, funds were also granted to the ANC trial economic group to conduct a study to predict the cost-effectiveness of the W.H.O. ANC programme in a setting in South Africa³⁵. The setting chosen was Umlazi Township, located in KwaZulu Natal province, 20 km South of the City of Durban. Six health centres provide primary health care in this township, five of which provided antenatal care at the time of the study. Prince Mshiyeni Memorial hospital, located in the township, is a large general hospital, and is responsible for roughly 20 health centres in the region. The ANC schedule follows the traditional 'Western' recommendations, although a large proportion of women report late during their pregnancies. The institutional delivery rate is about 60%³⁶. Prince Mshiyeni hospital is the main place where women from Umlazi deliver, and a small proportion deliver in the health centres.

Economic evaluation. An economic evaluation was included in the planning phase of the trial, and funding was provided to estimate the unit costs of maternity care in two of the countries (Cuba and Thailand) and also cost-effectiveness prediction in South Africa. The economic study³⁷, as a sub-component of the antenatal care trial, based its' aims and scope on the primary hypothesis of the trial, which contained a clear reference to the economic outcome. Therefore, the overall aim of the economic study was to assess whether the new programme of antenatal care was more cost-effective than the existing level of service, including costs to both the health service and the women of attending ANC.

5.2 Aim and objectives of empirical study

As was stated in the introduction, the overall thesis aim is to increase current knowledge about the strengths and weaknesses of alternative cost analysis and cost prediction methods, in the context of public health care systems, and with particular emphasis on developing countries. To fulfil this aim, costs of selected maternity services are estimated in the study settings; costs are compared and analysed; the generalisability of costs is examined; costs are predicted using selected methods; and cost predictions are

³⁵ A pilot study was conducted in South Africa to decide whether it could participate in the W.H.O. ANC trial; however, loss-to-follow-up rates after delivery were well above the acceptable level of 5%.

³⁶ This rate was obtained from the pilot study for the antenatal care trial, performed by Professor Ross. Of the roughly 40% of women that did not have an institutional delivery, only half responded to the request to contact the research centre of Professor Ross following delivery.

³⁷ See the methods paper in Appendix 3 for a fuller description of the economic component of the trial.

compared with estimated costs. With these in mind, specific data collection and analysis objectives were set, based on six research questions.

1. What are the costs of antenatal and delivery care in study countries?

- ❑ Measure physical resource use, and average and marginal costs of selected maternity services in a sample of health facilities in Cuba, Thailand and South Africa.
- ❑ Extract relevant health service use data from the W.H.O. data set to calculate the average cost per case (including care during pregnancy, delivery and the postpartum) for women in control and intervention arms in Cuba and Thailand.
- ❑ Collect relevant health service use data on a sample of women to calculate the average cost per case for current care in South Africa.
- ❑ Present US\$ costs using nominal exchange rates and purchasing power parity.

2. How robust are these costs?

- ❑ Evaluate critically the costing framework and economic study design, and identify important areas of data and model uncertainty.
- ❑ Conduct a sensitivity analysis and present ranges on unit and case costs to reflect uncertainty in cost estimates.

3. What is the variability of these costs?

- ❑ Present unit cost components by health facility and month.
- ❑ Present distributions of health service use and cost per case in each health facility, arm and country.
- ❑ Show the profiles of unit cost and cost per pregnancy, by resource type.

4. What factors account for cost variation?

- ❑ Examine causes of variation between health facility, trial arm and country, using those factors identified to cause cost variation in the literature review, for:
 - Health service use.
 - Resource use (per health service use).
 - Unit cost (average and marginal cost).
 - Case cost (using average and marginal cost).

5. *How accurate are cost predictions using alternative methods?*

- ❑ Predict costs in Cuba and Thailand using available methods, and judge the accuracy of these predictions.
- ❑ Predict costs in South Africa, and compare results.
- ❑ Discuss the strengths and weaknesses of cost prediction methods.

6. *What are the implications for those wishing to make cost predictions and interpret research?*

- ❑ To conclude what factors cause elements of cost to vary between setting, how much these relationships vary between setting, and therefore factors that affect the generalisability of cost data.
- ❑ To conclude which cost prediction methods are potentially best in different research settings.
- ❑ To conclude what measures are possible to increase the generalisability of cost data.
- ❑ To make recommendations based on these findings for researchers and policy makers.

The next three sections describe the methods of data collection and cost analysis.

5.3 Methods of data collection and cost estimation

5.3.1 Overview of data requirements and data sources

Table 5.1 classifies the data according to ‘types of data’ and ‘sources of data’. Data are classified by: cost, cost determinants, clinical information, patient characteristics and outcomes, and macroeconomic data³⁸. The three main data sources for this thesis are primary sources in the economic study, secondary sources in the economic study, and data extracted from the trial data set (see footnote to Table 5.1).

³⁸ All data tabulations and analyses were done using Microsoft Excel © spreadsheets, unless otherwise stated.

Table 5.1: Types of data and sources of data used in the thesis.

Type of data	Cuba and Thailand (both trial arms)	South Africa (current care only)
1. Aspects of cost	<ul style="list-style-type: none"> • Prices of resources • Quantity input for each activity • Overhead costs • Unit costs and cost profiles • Health service use • Total and incremental costs • Cost per pregnancy 	<ul style="list-style-type: none"> • Prices of resources • Quantity input for each activity • Overhead costs • Unit costs and cost profiles • Health service use • Total and incremental costs • Cost per pregnancy
2. Cost determinants	<ul style="list-style-type: none"> • Management practices • Wastage and inefficiency • Capacity use and throughput • Input:output ratios • Health facility size and services • Average length of stay • Structural quality indicators • Compliance with WHO protocol 	<ul style="list-style-type: none"> • Management practices • Wastage and inefficiency • Capacity use and throughput • Input:output ratios • Health facility size and services • Average length of stay • Structural quality indicators
3. Health provider information	<ul style="list-style-type: none"> • Content of new programme of ANC • Content of current ANC (guidelines) • Departures from clinical protocol • Referral patterns • Incentives to providers • Staff categories (qualifications, roles and pay scales) 	<ul style="list-style-type: none"> • Content of current ANC (guidelines) • Departures from clinical protocol • Referral patterns • Incentives to providers • Staff categories (qualifications, roles and pay scales)
4. Patient and population level information	<ul style="list-style-type: none"> • Numbers of health service use • Rates of risk and morbidity • Socioeconomic and demographic variables 	<ul style="list-style-type: none"> • Numbers of health service use • Rates of risk and morbidity • Socioeconomic & demographic variables
5. Macroeconomic information	<ul style="list-style-type: none"> • <i>Nominal exchange rates</i> • <i>Inflation rates</i> • Purchasing power parity 	<ul style="list-style-type: none"> • <i>Nominal exchange rates</i> • <i>Inflation rates</i> • Purchasing power parity

TABLE KEY: In bold: Primary data measured by the economic study.
In italics: Data collected from secondary data sources in economic study.
In normal: Data collected by the antenatal care trial.

5.3.2 Health service use data sources

Health service use data on all trial women in Cuba and Thailand were extracted from the trial data set (from SPSS for Windows © files), and presented by health facility, by trial arm and by country. Mean and median values and distributions are provided for health service use in tables and histograms. Confidence intervals are estimated using ± 1.96 S.E.. For inpatient antenatal care, the average inpatient days per admitted case and per trial woman are presented. For Cuba, inpatient admissions are split by whether they classify as low or high risk (as there are separate wards for women of different risk). Similarly for neonatal care the average length of stay is presented for both admitted cases and for all trial babies. For postpartum stay the mean and median length of stay following vaginal delivery and CS and reported separately.

Similar data were presented for South Africa. However, because the trial was not conducted in South Africa, arrangements were made to conduct an additional survey. In this survey, data on 800 women delivering in Prince Mshiyeni Memorial hospital was extracted from antenatal and labour/delivery cards, and entered in the W.H.O. trial summary forms. However, for logistical reasons this was not a prospective survey. Instead, records were collected in chronological order from the record room of the hospital, starting in January 1998, until 800 forms were filled in. Of these 785 had complete data.

5.3.3 Unit cost estimation

Costing health services requires several decisions to be made concerning the costing methodology. These include deciding which cost centres to estimate unit costs for, the costing approach (whether top-down or bottom-up costing), the methods for physical resource measurement and monetary valuation, the methods of cost allocation across cost centres, and the choice of sample size. These are discussed below in turn.

Table 5.2 shows the types of health care in each health facility for which unit costs are estimated. In Thailand, all types of care are provided in the district hospitals located in Khon Kaen province, and these costs are estimated from primary sources in the costing study. The other three hospitals in Thailand provide all types of maternity care (mainly to high risk women) in Khon Kaen city. In Cuba, only outpatient care is provided to women in the policlinics, and therefore inpatient care costs were collected in America Arias hospital, over 70% of trial women received their inpatient care. In South Africa, five health centres in the jurisdiction of Prince Mshiyeni were chosen as the sample health facilities, where outpatient care and normal vaginal delivery care are provided. Prince Mshiyeni hospital provides inpatient care, where unit costs were collected.

Table 5.2: Health facilities and types of care where unit costs were estimated.

Country and health facilities	Number of facilities	Type of heaalth care ¹						Type of data
		OPV	IPD	VD	CS	PPD	NND	
Thailand								
District hospitals	12	√	√	√	√	√	(√)	Primary
Sririgarind University hospital	1	√	√	√	√	√	√	Secondary ²
Khon Kaen hospital	1	√	√	√	√	√	√	Secondary ³
Regional hospital	1	√	√	√	√	√	√	Generalised ⁴
Cuba								
Policlinics	12	√	x	x	x	x	X	Primary
America Arias hospital	1	√	√	√	√	√	√	Primary
Other maternity hospitals	8	√	√	√	√	√	√	Generalised ⁵
South Africa								
Health centres	5	√	x	√	x	x	X	Primary
Prince Mshiyeni hospital	1	√	√	√	√	√	√	Primary

¹ OPV: outpatient visit; IPD: inpatient day (during pregnancy); VD: vaginal delivery; CS: caesarean section; PPD: postpartum inpatient day; NND: neonatal intensive care day. '√' and 'x' indicate that the type of care in the column heading is / is not (respectively) provided at the health facility (-ies) in the corresponding row. '(√)' means that neonatal intensive care costs were approximated by adult IPD costs, as incubators were in the same ward.

² Data source: a costing study conducted in 1989 (Kosuwun et al 1989). Unit costs were adjusted to 1998.

³ Data source: a costing study conducted in 1996 (Wilaiporn 1996). Unit costs were adjusted to 1998.

⁴ Unit costs at the regional hospital were estimated as the average of Sriragarind and Khon Kaen hospitals

⁵ Unit costs of all other maternity hospitals were assumed to be the same as in America Arias hospital

The choice of costing approach used in the ANC trial was described and justified in Mugford, Hutton and Fox-Rushby (1998). Unit costs were estimated using the top-down approach for all types of health care in all countries, except caesarean section in Thailand³⁹. A step-down allocation procedure was used that best reflected the flow of services between departments, and that could be applied in a standardised way in all countries. Costs were collected to refer to the period September 1997 to April 1998 in Cuba (8 months of unit cost data), October 1996 to December 1997 in Thailand (15 months of unit cost data), and January to April 1998 in South Africa (4 months of unit cost data)⁴⁰. The information collected for each resource ingredient is presented in Table 5.3 below.

³⁹ A bottom-up costing approach was used for caesarean section in Thailand, because the operating theatres in the district hospitals were general in nature, and therefore the top-down costing approach would not have captured specifically the unit cost of a CS.

⁴⁰ The original target for the number of months of unit cost data was 12 months in all countries. In Cuba, less were obtained as research time for data collection was underestimated; in South Africa, less were obtained as data on patient outcomes had to be collected within the same research budget; in Thailand, more were obtained, to collect unit cost information in the period after the economic crisis in late-1997.

Table 5.3: Types and frequency of data collected for each health care resource

Resource ingredient	Types of data collected			
	Physical resource quantity	Frequency ¹	Monetary value	Frequency ¹
Staff	All staff in health facility by cost centre	Monthly	Monthly gross salary Value of accommodation	Monthly
Equipment	All equipment in health facility by cost centre, purchase year, length of life	One-off	Purchase price (some) Current price (most)	One-off
Drugs	Drugs consumed by a sample of 15 pregnant women per facility	One-off	Current price	One-off
Materials	All materials consumed by relevant cost centres	Monthly	Current price	Monthly
Utilities	Number of utility outlets in each cost centre	One-off	Monthly cost for each utility in entire health facility	Monthly
Buildings	Floor space in each cost centre, construction year, length of life	One-off	Construction cost (most) Monthly rental value (some)	One-off

¹ 'Monthly' means that information was collected for each calendar month for the data collection period. 'One-off' means that data collection was needed once only to cover the whole data collection period.

The identification of the opportunity cost of resources represented a challenge, as the financial cost paid for resources does not necessarily equal the opportunity cost (Garber et al 1996). The general approach of Drummond et al (1997) was adopted in this thesis, where the existing market price was used unless there was some particular reason to do otherwise. Drummond et al (1997) argued that the main reason to 'do otherwise' was if the analyst is convinced that to leave prices unadjusted would introduce substantial bias into the study, but only if there is a clear way of making the adjustment. Therefore, the existence of market failure was assessed in all resource markets, as indicated by the existence of monopoly or monopsony power, government subsidy, or cross-subsidy. Also, the impact of government-imposed restrictions on trade (internal or external) such as taxes was examined. In order to increase the consistency in collecting information on opportunity cost, and give the approach some background in economic theory, a step-by-step approach was used to identify the appropriate price of the resource to approximate opportunity cost, illustrated in Box 5.1. This approach is based on the general approach of the development project appraisal literature for identifying the opportunity cost, or 'shadow price' (Gittinger 1984, Curry and Weiss 1993, Layard and Glaister 1994, MacArthur 1997). This approach involves first identifying if the good has a world price (either a traded good or a potentially traded good), and if not, whether it has a price in the local economy that represents a competitive market rate.

Unit costs are represented by both average and marginal costs, and are presented for all relevant cost centres in US\$ at nominal exchange rates and at purchasing power parity

(PPP). Nominal exchange rates were collected on 8 January 1998, as this was the mid-point of the trial, and was the point in time that was common to data collection periods in all countries. However, as US\$ values converted using nominal exchange rates do not necessarily reflect the relative cost to the countries incurring the costs (compared to other goods), an alternative conversion method was considered essential for making cross-country cost comparisons. Therefore, PPPs were also used. However, as PPP rates were not available for Cuba from international sources, a home-made PPP measure was constructed that allowed a fair and consistent comparison between countries taking into account local purchasing power (see Appendix 4 Table 4.1 for description of method and results). Cost profiles are also presented, by resource, and by department (direct health care, technical support, laboratory, administration, general). Also, the coefficient of variation (standard deviation ÷ mean) is presented to show the extent of inter-month variation in each cost centre.

To allow testing of whether unit costs vary between health facilities, some measure of variability within each cost centre is needed to allow calculation of confidence intervals. Variability in unit cost can come from two sources: inter-patient variability, or variability over time. However, the former could not be presented, as unit costs were not collected on individual patients. Therefore, variability was calculated using unit costs from the number of months for which unit costs were estimated⁴¹. However, in interpreting and using these confidence intervals, it is recognised that this measure of variability does not reflect variability in all the resource ingredients or by patient.

⁴¹ Confidence intervals are based on the inter-month variability using the 't' distribution due to the small number of observations (months of data), using the formula $[\text{mean} \pm (t' \times s/\sqrt{n})]$, where t' is taken from the t distribution using 2-tailed α at 0.05 and degrees of freedom $n-1$; s is the standard deviation, and n is the number of months of data. These confidence intervals are based on the premise that average costs for each month are independent of each other (that is, there is no predictable seasonal variation), which is confirmed by examining the time patterns of cost and activity data.

Box 5.1: Step-by-step approach to identify the opportunity cost of health care resources.

Question 1 - "Is the resource imported?"

Answer 1(a): Yes, it is imported. The good is a Traded Good (TG) and has an international price that should include carriage, insurance and freight (CIF). To this should be added the local transport and distribution costs (= 'domestic margin') to approximate the local opportunity cost. Profit elements, import subsidies, and import taxes are 'transfers' and therefore subtracted from cost. FINISH.

Answer 1(b): No it is not imported, or its' origin is unknown. Go to Question 2.

Question 2 - "Could the resource be imported?"

Answer 2(a): Yes, it could be imported. The good is classified as a Potentially Tradeable Good (PTG) and also has an international price, which can be obtained on the international market if it were exported (giving foreign exchange) or if it were imported (giving the minimum cost of obtaining it). If this is available, then the domestic price (production and transport cost) should be ignored, as it does not reflect the opportunity cost of the good, *assuming the good could be imported*. On the other hand, if the good is restricted by government quotas, and the policy is unlikely to change in the near future, then it may be unrealistic to value the resource in this way, and the domestic price should be used. Also, if the international price is not available, or too difficult to find, then the domestic price should be used. The characteristics of the domestic market should be studied (e.g. whether it is a government or private supplier, and whether it is sold at a subsidised rate, at cost, or at a profit). END.

Answer 2(b): No, it cannot be imported. The good is classified as a non-traded good (NTG), and is most likely to be labour, utilities and buildings. Go to Question 3.

Question 3 - Is there a market and price for the resource?

Answer 3(a) Yes, there is a market and price for the resource. This means that a clear and objective way of valuing price is needed. For example, staff salaries, telephone bills, and building rental indicates that some market and price system exists for the resource. Once this value has been found, go to Question 4.

Answer 3(b): No, there is no market or price system for the resource. This means that another method is required for estimating the opportunity cost of the resource. Go to Question 5.

Question 4 - Does the cost or price approximate the opportunity cost?

Answer 4(a): Yes, the cost or price does approximate the opportunity cost. Then it is assumed that a perfect market exists, or at least there are no significant government subsidies, or monopoly position. Therefore, no adjustments are necessary, and this cost or price can be used in the economic evaluation. END.

Answer 4(b): No, the cost or price does not approximate the opportunity cost. Then a clear and objective way of making adjustments is required. For example, are data available from elsewhere that better approximates the opportunity cost, such as private sector wages instead of public sector wages? A good knowledge of the market conditions is needed, including both supply factors (e.g. is the resource in fixed or variable supply?) and demand factors (e.g. what is the strength of local demand for the resource?). It should also be noted whether the non-traded good contains any traded goods, because if it does they should be valued at the shadow exchange rate. END.

Question 5 - Can the cost or price of the non-market good be approximated from other sources?

Answer 5(a): Yes, the cost can be approximated using other data sources. Then assess the relevance or appropriateness of the other source for valuation of the resource. For example, volunteer labour input can be approximated by the opportunity cost of a health worker doing the same job. END.

Answer 5(b): No, the cost cannot be approximated using other data sources. Then it may be best to interview health care staff or patients about willingness to pay for certain resources, or make them give an estimated market value. If this is impossible, then leave the resource out altogether, and make a note in the tables to say why it was left out. END.

5.3.4 Cost per pregnancy estimation

Cost per pregnancy is calculated for all women not excluded from the data analysis by the trial criteria⁴². Cost per pregnancy (CPP) is calculated as follows:

$$CPP_k = \sum_{i=1}^n \sum_{j=1}^m [HSU_{ij} \times UC_{ij}]_k$$

Where

HSU_{ij} = Health Service Use of the i^{th} type of service in the j^{th} facility of the k^{th} woman

UC_{ij} = Unit Cost of the i^{th} type of service in the j^{th} facility

i : As described above, health services included in cost per pregnancy were: outpatient and inpatient antenatal care, delivery care, postpartum care for the woman, neonatal intensive care.

j : As described above, there were six control and six intervention arm facilities which women were randomised to in Cuba and Thailand, and five clinics in South Africa.

k : There were a total of 5604 women in Cuba, 6369 women in Thailand and 785 women in South Africa included in the cost per pregnancy calculations.

Average cost per pregnancy (ACPP) is calculated for each woman, each health facility (the woman 'belongs' to the health facility where she was recruited to the ANC trial), and both trial arms, using the average cost data. Likewise marginal cost per pregnancy (MCP) is calculated using marginal costs. Comparing CPP in control and intervention arms gives the incremental cost (new versus current antenatal care). Mean and median values and distributions are provided for CPP at each level of aggregation in tables and histograms. Median cost per case is important to present in addition to mean cost, due to the skewed nature of cost data, and gives a more realistic view of central tendency. However, for the purposes of decision making, mean values are more appropriate, as they allow the analyst to calculate the total budget requirement of an intervention, and therefore mean values are the main focus of the cost analysis. Confidence intervals are approximated using ± 1.96 standard errors of the mean value. Although cost per pregnancy distributions are expected to be positively skewed, standard errors were not estimated using the bootstrapping method for two reasons (1) distributions have to be very seriously non-Normal for bootstrapped estimates to be essential and (2) because confidence intervals are not used for testing differences between facilities. Mean values

⁴² Women who had abortions, who were not pregnant and who were lost-to-follow-up are excluded.

are also compared between trial arms using log costs, to estimate mean difference taking account of the skewness of the data.

5.3.5 Health service performance and description

Health service performance and description data were collected to explain cost size and variability, and provide a context for making cost generalisations. Data collected are listed in Table 6.1. They include qualitative information on health care structure and management approach, health care content and quality, and some quantitative data on population characteristics (such as socio-demographic variables and risk status) and provider performance (such as throughput and capacity use).

5.3.6 Project management

There were economics teams in the UK, Cuba, Thailand and South Africa (see Appendix 4 Table 4.3 for details). The UK team was responsible primarily for setting up the economics study, supervising the other teams and providing technical support, liaising with the antenatal care trial Steering Committee, and analysing the final data set. The local teams were responsible for organising the data collection in each of their countries, and reporting to the UK economics team. Several field visits were made by the UK economics team during the study. Guy Hutton (GH), and sometimes Miranda Mugford (MM) or Julia Fox-Rushby (JFR), made at least one trip to each country in each of 1996, 1997, and 1998 (see Appendix 4 Table 4.4). While the main purpose of these trips and the data collection was to meet the primary objective of the economic evaluation alongside the W.H.O. ANC trial, other information was collected during these trips and meetings held with key researchers and policy makers for input to the thesis methods and results. Also, additional cost data required for the thesis were collected by both the local economics teams and by GH during field visits. The project was managed from the UK by GH, MM and JFR, with monthly project meetings and regular email and fax contact with the centres, for progress monitoring and trouble shooting. Also, there were five steering group meetings and one principal investigator meeting between 1995 and 1999, all of which were attended by the UK economics team.

5.4 Analysis of robustness of costs

Uncertainty exists in both health service use and unit costs, which make up cost per pregnancy. Therefore it is important to examine separately the robustness of each of

these components, to assess whether data uncertainty or changes in model assumptions changes or influences the results and conclusions of the cost study. Conclusions of interest to be examined are at the within and between country levels: (1) does uncertainty lead to different cost per pregnancy between trial arms, and therefore a different incremental cost? (2) does uncertainty lead to different cost per pregnancy between countries, and therefore different conclusions regarding cross-country differences?

5.4.1 Uncertainty in health service use

At the within country level, it is useful to calculate what changes in health service use in the intervention arm would be required for a change in incremental cost to 'no difference' (i.e. mean difference equal to zero). For this, a threshold analysis is conducted. For example, if in the base case the W.H.O. programme costs less than the current programme, what increase in caesarean section rate or number of ANC visits is required for there to be no cost difference between trial arms? The threshold rates for each type of health service use would then be compared with the upper 95% confidence limit measured by the trial, to make conclusions about the likelihood of such a value being observed. A similar analysis is presented briefly for the between country level, where threshold values are obtained where no significant differences in cost per pregnancy exist between countries.

5.4.2 Uncertainty in unit costs

Uncertainty in unit costs in this study is represented using sensitivity analysis, where uncertain data inputs and costing methods are identified, and alternative methods or values are substituted to give a new range on unit cost (Briggs et al 1994). Therefore, the resulting ranges represent a 'deterministic' distribution (O'Brien et al 1994), as there are limited opportunities for attaching probabilities to alternative values. However, in addition to the one-way testing of alternative values or methods, several uncertain elements are combined in a multi-way sensitivity analysis.

For the within country analysis, there are limited options for identifying differences in degrees of uncertainty between trial arm, as identical costing methods were applied to both intervention and control health facilities. The only type of care whose unit cost could possibly be influenced by the W.H.O. programme is outpatient antenatal care (as

the programme was unlikely to influence inpatient health service use significantly enough to cause changes in unit costs). Given that the top-down costing approach might not have picked up changes in unit costs under the new programme, a threshold analysis is performed to identify what the outpatient ANC unit cost would have to be for there to be a zero incremental cost per pregnancy. The threshold unit cost is compared with the range of unit costs observed in intervention health facilities, and conclusions made about the likelihood of these occurring.

For the between country analysis, it is possible that different levels of uncertainty could have been partly responsible for unit cost differences, and ultimately cost per pregnancy differences. Therefore, aspects of the costing study design and implementation were evaluated, and sources of uncertainty classified under four main types (Briggs et al 1994): (1) No or insufficient observations on a parameter. (2) Inaccuracies in recording systems. (3) Uncertainty over which is the best method to value a parameter. (4) Uncertainty over generalisability of values across settings. Appendix 4 Tables 4.5 to 4.8 provide details of the degree of uncertainty in each source found in the each country, and includes details of the base case value or costing approach, and the possible alternative value(s) or approach(es).

While many sources of uncertainty were found, some were concluded to be relatively important (either because the uncertainty is minimal or the overall impact on costs is likely to be small), and therefore only a few areas of uncertainty were tested (written in bold in Appendix 4 Tables 4.5 to 4.8). The problem with providing alternative values or approaches is that they should be backed up with evidence (and probability of occurrence if possible) (Drummond et al 1997). However, due to the lack of such data for many areas of uncertainty, many of the ranges or alternatives are assumed for convenience. In fact, it is likely that the ranges chosen overestimated the true ranges, and therefore the resulting ranges on unit costs are unlikely to occur. The variables chosen for inclusion in the multi-way sensitivity analysis were: (1) increase cost of tradeables by 50% to account for possible unfavourable exchange rate variations or changes of world supplier. (2) Increase wages by 50% to reflect an alternative value for opportunity cost. (3) Halve and double the length of life of capital goods used in the base case, to reflect uncertainty and variation in the actual length of useful life of these

goods. (4) Insufficient number of months in Cuba and South Africa, where adjustments are made based on variability in Thailand to account for the smaller sample size in months of unit cost data. In addition to these sources of uncertainty, results are presented at the black market exchange rate for Cuba and an alternative exchange rate (nominal exchange rate in May 1999) for Thailand and South Africa.

5.5 Analysis of cost variation

Following the distinction between costs and the identification of components of total cost (introduced in Chapter 1 Box 1.1 and Figure 1.1, and discussed in detail in the literature review chapters), four types of cost were chosen for analysis of variation. These were health service use, resource use, unit cost, and cost per pregnancy (case cost). The purpose of separating cost per pregnancy into its' component parts is that it helps explain similarities and variations in cost per pregnancy, a process which contributes to understanding whether such costs can be generalised or predicted between settings. In addition, analysis of health service use and resource use, which are presented in non-monetary units, allows cross-country comparisons without the complication of currency conversion, and the associated burden of interpreting costs presented in a common currency such as US\$.

The purpose of this section is to describe how each type of cost is analysed. Before this, some general principals and procedures are presented. The first section distinguishes between different levels of cost variation, and clarifies which are of most interest to cost generalisability. The second section discusses briefly the procedures for judging significance in cost variation, distinguishing between statistical and economic significance.

5.5.1 Levels of cost variation

This section briefly outlines which variations are studied for the four types of cost and why. Table 5.4 tabulates the various levels of variation for each type of cost.

Table 5.4: Levels of comparison for different cost components

Cost component	Between women groups	Between facility	Between trial arm	Between country	
				Intervention	Control
Health service use	A	C	G	K	P
Resource use	No data	D	H	L	Q
Unit cost	No data	E	I	M	R
Cost per pregnancy	B	F	J	N	S

(the letters A to S are referred to in the text below)

Comparison between groups of women: As stated, unit costs were not measured on an individual woman basis (due to the adoption of the top-down costing approach) whereas health service use was (A), allowing for calculation of cost per pregnancy (B) for all women. While analysing health service use (A) determinants on a patient level using multiple regression analysis may give interesting results, the picture would be incomplete as only one type of health service use can be examined as the dependent variable in a single regression equation, and therefore the focus of the regression analysis is on cost per pregnancy (B) as the dependent variable.

Comparison between individual health facilities: Although health facilities are generally homogeneous within country with respect to approaches to health care (Piaggio et al 1998), it is possible that cost components vary significantly between health facilities. Therefore, comparison of relevant aspects of health facilities may help towards an understanding of why costs vary between health facility (if they do) and has important implications for the generalisability of the costs results within country. For example, if cost per pregnancy varies unexplainably between health facility (F), this throws doubts on the usefulness of the results for policy makers. However, if variations do not exist, or variations can be explained, such as unit cost variation being caused by different staffing levels (D) or health service use (C), the results have some use for policy makers. Therefore, variations in all types of cost are examined.

Comparison between trial arm: The comparison between trial arms is important to examine in making conclusions about whether the W.H.O. programme has brought about changes in cost per pregnancy (J). However, note that changes in cost per pregnancy can come from any one of the three components (price, resource use, health service use), and that if cost per pregnancy remains unchanged between arm, it does not mean differences do not exist in sub-components. For example, the new programme

may involve less antenatal visits (G) but more resource use per visit (H), thus balancing each other out to have no overall impact on cost per pregnancy. Therefore, it is important to understand the behaviour of each cost component, to know their contribution to change in cost per pregnancy. Also, the threshold analysis (described earlier) provides information to allow tentative conclusions about the likelihood of a zero mean incremental cost occurring.

Comparison between country: The final comparison, and one that is not undertaken until the results are understood completely at the country level, is between countries. As shown in the final two columns of Table 5.4, two types of comparison are possible, each with their uses. The first is a comparison between intervention arms between country, as this shows whether the new programme has been adopted in a similar way, with similar health service use (K), resource use (L), or even unit cost (M). The second, comparison between control arms, is also useful in that heterogeneity between country is understood, and the relative costs in the intervention arms interpreted in the light of the 'starting point'. The content of the control arms may help explain disparities in health service use in intervention arms in different countries.

5.5.2 'Significant' variation

For the purpose of this thesis, a distinction is made between two types of significance. The first, statistical significance, is useful for saying with a pre-defined level of confidence whether a difference could be due to chance. The second, economic significance, is useful for saying whether a difference is economically meaningful. Judgements about both types of variation are important at the cost analysis stage, because if differences are not significant, either statistically or economically, then it is less worthwhile to examine the causes of these differences.

For the determination of statistical significance, there is a recognised method of judging significance using statistical tests based on assumptions about the sample distribution approximating the population distribution (Gujarati 1999) (described for each type of cost below). However, the determination of economically meaningful differences is not as clear-cut. This is because economic value is a highly context-specific phenomenon, whether absolute or relative values are used. For this thesis, a criterion for judging

economic meaning must be set. However, few precedents were found in the health economics literature (Drummond and O'Brien 1993, Birch 1997).

While absolute value may be preferable on pragmatic grounds (such as whether the cost difference is enough to change a decision), data are not available from the study settings on the cost differences at which decision makers would change their decision, whether at the unit cost or the cost per pregnancy level. Relative value, on the other hand, is potentially a more generalisable measure, but is also limited by the fact that the economic meaning of a percentage change in cost is highly context-specific. It also suffers the disadvantage that if the percentage difference is high, but it is the percentage of a very small amount, economic meaning is concluded when in fact it may not exist. However, as it is the only criterion left available to judge cost differences in this thesis, relative value is used. The next question concerns: relative value of what? As antenatal care is the focus of the current thesis, it seems appropriate to choose the cost of an antenatal visit as the measure of relative value. Differences in unit costs between health facilities are therefore judged on the basis that a difference in unit cost of at least one antenatal visit is interpreted as economically meaningful. Differences in cost per pregnancy between trial arms are judged on the basis of equivalent numbers of antenatal visits, and again, differences in cost per pregnancy of at least one antenatal visit is interpreted as economically meaningful. However, this is recognised as arbitrary, and the costs of different types of health service and implications for economic significance are discussed.

5.5.3 Analysis of health service use variation

The first question concerns “to what extent are differences in health service use significantly different?” Comparisons of health service use are made at the health facility level for variables with distributions using the t test⁴³ which allows for the cluster effect, and at the trial arm and country levels using the F test. For dummy health service use parameters, where the answer is either ‘yes’ or ‘no’ (e.g. caesarean section rate), the chi-squared test is used. The second question concerns, if variations are statistically different, “what factors are causing these variations?” Appendix 4 Tables 4.9 and 4.10 summarise those variables identified from the literature review in Chapter 4 and examined in the thesis that potentially explain rates of health service use, using

patient and provider factors respectively. Most of these variables are relevant for uptake of outpatient ANC, but some (e.g. costs of services, risk levels, morbidity) are also relevant for explaining variations in inpatient ANC, delivery type and neonatal admission.

Data are collected and compared on factors affecting health service use, such as geographical access, health service costs, transport costs, familiarity with health services, risk levels and morbidity. For example, geographical accessibility is examined by comparing the average distance from clinic for different populations, as well as average transport travel time, and transport availability and cost. The sources for these data are trial data, including the women's cost survey, satisfaction survey, and the main trial summary forms. It should be noted that for all of these sources, the studies were designed to make conclusions about differences between arm, and therefore differences between individual clinics can only be examined in an exploratory manner.

Appendix 4 Table 4.10 lists the provider factors under study that potentially influence all types of health service use. These include financial incentives to providers, compliance with guidelines, quality of care, and attitudes to risk. For many of these variables there is simply a yes/no answer. Thus a picture is built of which clinics or countries are expected to have the higher or lower levels of health service use.

5.5.4 Analysis of resource use variation

In order to identify and explain unit cost differences, resource use is presented in the form of an input:output ratio. For some resources this is more difficult to do, for two main reasons: (1) the top-down approach to costing was used and therefore exact uses of some resources for individuals was not recorded, such as materials and equipment, and (2) some resources cannot be measured on an individual level without extremely detailed data collection, such as the use of electricity or of furniture per patient. Therefore for some resources, ratios are not presented. The methods of analysis for each type of resource are shown in Table 5.5.

⁴³ The t test fails only if distributions are severely non-Normal.

Table 5.5: Cost analysis methods to analyse variation in physical resource units

Resource	Analysis methods
Staff	<ol style="list-style-type: none">1. Staffing structures in all participating health facilities are tabulated and discussed, and nurse/doctor and health care/support staff ratios are provided.2. Input/output ratios are tabulated and compared graphically between health facilities and with occupancy, and differences examined.3. Data envelopment analysis is used to estimate technical efficiency of outpatient ANC provision within each country, and inpatient care in Thailand, using average monthly staff numbers as the input and average monthly throughput as the output. The model is run under assumptions of variable and constant returns to scale.
Equipment	General profiles of equipment in participating health facilities are compared.
Drugs	For outpatient care, the results of a drug survey (using the antenatal records of a sample of women in each health facility) are used to tabulate types and quantity of drugs prescribed to women in Cuba and Thailand, and general trends discussed.
Materials	Aspects of material usage are discussed, and conclusions made about differences.
Utilities	A brief description is given of utility use.
Buildings	A brief description is given of building use, and input/output ratios are tabulated and compared (throughput per square metre per month).
Other	Bed occupancy rates and average length of stay are compared using the Lasso method (Lasso 1986).

5.5.5 Analysis of unit cost variation

The first stage in unit cost analysis is to tabulate and compare unit costs, identifying statistically significant differences. The statistical method used for comparing unit costs depends on the type of comparison. First, *unit cost comparisons between any two cost centres* are made using the F test, as it gives more precision than a t test. A ‘n’ by ‘m’ ANOVA is used, ‘n’ being the number of facilities and ‘m’ the number of months of data. The interpretation of the results from these comparisons based on month-to-month instead of patient-by-patient variation has already been discussed. Second *unit cost comparisons between two groups of facilities*, such as trial arms, are also made using the F test, where a ‘p’ by ‘q’ ANOVA is used, ‘p’ being number of groups being compared and ‘q’ the number of health facilities in each group. This test takes into account the cluster design of the ANC trial. Confidence intervals are provided for the differences. Economically meaningful differences are judged using the criterion ‘the percent cost of an ANC visit’.

In the literature review, a number of possible causes of unit cost variation were described and evidence for their impact on unit cost was presented. Not all the methods identified in the review are used in this thesis, due to data limitations to explain differences (case-mix and quality of care, which receive only superficial attention), and

to minimal expected impact in the study settings (economies of scope, as services offered did not vary between randomised health facilities within country). Table 5.6 summarises the methods that are used to explain unit cost variations, and the hypothesised impact of different factors on unit cost (from Chapters 2 and 4).

Table 5.6: Impact of hypothesised factors on unit cost and methods for assessment

Factor	Hypothesised impact on unit cost of factor	Methods for assessment
X-efficiency	Wastage (X-inefficiency) increases unit cost	<ol style="list-style-type: none"> 1. DEA (inputs: average monthly staff costs and total cost of capital stock; output: average activity data). 2. Tabulate staff ratios with unit cost 3. Recalculate unit costs using staff ratio of most productive health facility
Returns to the variable factor	The presence of spare capacity increases average cost	<ol style="list-style-type: none"> 1. Tabulate monthly throughput & unit cost 2. Re-estimate costs at 80% & 100% capacity
Economies of scale	Larger providers may use resources more productively, thus lowers AC	<ol style="list-style-type: none"> 1. Tabulate health provider size & unit cost 2. Tabulate % overhead cost & unit cost
Input mix	Greater resource intensity increases unit cost	<ol style="list-style-type: none"> 1. Tabulate resource intensity ratios & prices
Case-mix	More severely ill patients increase unit cost	<ol style="list-style-type: none"> 1. Tabulate risk conditions & unit cost 2. Tabulate morbidity levels & unit cost
Prices	Higher prices increase unit cost	<ol style="list-style-type: none"> 1. Compare unit cost ratios and price ratios 2. Recalculate unit costs based on prices in other countries
Costing methodology	Inappropriate methodology reduces the accuracy of unit cost	<ol style="list-style-type: none"> 1. Critically evaluate costing methods 2. Examine differences in costing methods
Uncertainty	Affects the size and confidence intervals of unit cost (either direction)	<ol style="list-style-type: none"> 1. One-way and multi-way sensitivity analysis (described earlier)

The main analyses expected to explain unit costs are data envelopment analysis⁴⁴ (to estimate a technical efficiency score for outpatient care in all countries, and inpatient care in Thailand), recalculation of unit costs using staff productivity of most efficient health facility, recalculation of unit costs under assumptions of operating at optimal (80%) and full (100%) capacity, examination of economies of scale using cross-sectional data, and analysis of input mix. Case-mix differences using morbidity profiles are also examined. Also, for the between country unit cost comparison, the impact of price differences on unit costs is explored, and unit costs are compared under alternative costing and currency exchange methods.

5.5.6 Analysis of cost per pregnancy variation

There are four stages in analysis of cost per pregnancy variation. First, statistically significant differences are sought in average cost per pregnancy (ACPP), marginal cost

⁴⁴ Using IDEAS software 6.0.2 Standard, 1 Consulting Inc ©.

per pregnancy (MCP) and median values. The threshold analysis (described earlier) is presented to make conclusions about the robustness of the differences identified. Second, cost per pregnancy at the facility, arm and country levels are tabulated graphically with health service use rates, as well as unit costs, to identify which are most responsible for cost per pregnancy variations. Third, women are grouped by case-mix (risk factors and events) and compared to see which ones appear to predict cost per pregnancy using bivariate analysis (using the Pearson correlation coefficient). While it is recognised that bivariate analysis does not take into account multiple determinants of cost, it is potentially useful for identifying variables to be included in multiple regression analysis (MRA). Fourth, multiple regression analysis is performed, the methods of which are described next.

The purposes of the regression analysis are: to understand and explain the variation in cost per pregnancy (the dependent variable) in study countries in terms of hypothesised determinants of cost (independent variables); and to use these results to predict costs in other settings. This thesis uses several principles recommended by econometricians in model building and interpretation (McCloskey and Zilliak 1996, Gujarati 1999), described in Chapter 3. The rest of this section is outlined as follows. First, the dependent and independent variables are listed and justified, with recourse to economic theory. Second, the various approaches to running the regressions are described, and the approach(es) to be used chosen and justified. Third, tests done on the regression results are described, to check the best-linear unbiased estimator (BLUE) properties of the model. Fourth, the approach to interpretation of the results is described. The methods used for the application of the results to predict costs in the same and other settings are described in the next section, under 'cost prediction methods'.

Choice of dependent variable in MRA

Costs are combined for several types of maternity care, to capture the 'cost per pregnancy'. These include outpatient and inpatient antenatal care, delivery care, postpartum inpatient stay, and neonatal intensive care. While each of these could be chosen as dependent variables, the purpose of this thesis is to predict the overall costs of the W.H.O. antenatal care programme. Countries are analysed separately. While all women from both trial arms are included in the regression, there is a dummy variable

for trial arm. Due to the skewed distribution of most cost data, and the distribution of cost per pregnancy is no exception, data are transformed to log values or log log values, and if the error term is still not adequately normally distributed, the maximum likelihood estimator approach is used. If the log of total cost approximates a normal distribution, then no alternative measures such as bootstrapping are required.

Choice of independent variables in MRA

In specifying the regression model, the factors that are most likely to have a relationship with the dependent variables are considered, and the expected sign predicted, using economic theory as the guiding principal. Second, scatter plots are used to confirm these relationships. Univariate regression analysis is also used to give an indication of the expected regression coefficients. Consideration is given to those variables that should remain in the model irrespective of whether they are statistically significant.

Following the results of previous studies reviewed in the literature (Chapter 3), independent variables are classified under women's risk characteristics (at the start of pregnancy), pregnancy and delivery 'events' (morbidity or predictors of health service use), provider characteristics (where women receive their care), and health service use by the women. Appendix 4 Tables 4.11 to 4.13 give the variables available under each of these four categories, with their expected relationship to cost, expected size, expected collinearity with other variables, and variable interpretation (dummy or continuous) described for each variable.

Some variables are not included, such as tetanus immunisation and iron supplementation, as there is minimal variability between women. A quality of care variable was not estimated, therefore the results implicitly assume identical quality between health providers. Input prices, sector of ownership, and rural/urban location are not included as they do not vary within the same country. Finally, neonatal death is not included due to the very low occurrence (<0.1%).

Appendix 4 Table 4.11 shows 11 a priori risk factors. For all except the age and previous pregnancy variables, an increase is likely to be associated with an increase in costs. This includes number of years at school, as education is more likely to increase

uptake for services than have the opposite effect. The main concern for multicollinearity for these risk factors is between previous abortion/stillbirth/LBW baby/surgery with 'last pregnancy adverse outcome'. Also, previous adverse outcomes are likely to be associated with higher age as older women have higher parity.

Appendix 4 Table 4.12 shows three main pregnancy events as regressors – gestational age at first visit (before or after 20 weeks), referral to a higher level of care during pregnancy, and an adverse event during pregnancy. The latter two are tested for correlation. Several events around delivery are also tested for their influence on cost per pregnancy, including preterm, postterm, prelabour rupture of membranes, induced labour, breech presentation at delivery, elective CS, and adverse diagnosis at labour. Again, correlation is assessed between these variables. Postpartum information includes birth weight, apgar scores at 1 and 5 minutes, congenital malformation, and the presence of postpartum syphilis or anaemia. Generic measures of case-severity or diagnostic-related groups are not used because they are poor predictors of cost, and also these data are not available from the antenatal care trial.

Appendix 4 Table 4.13 also shows a selection of provider characteristics, including whether the new or old ANC programme is being practised, staff efficiency in out- and inpatient departments, occupancy rates, and health provider size (for economies of scale). The inclusion of such predictors of average cost means that average costs themselves are not included. Also, health service use variables are included for the main types of health care, including the number of antenatal visits, and dummy variables for whether a woman was admitted during pregnancy, the type of delivery, and whether her baby was admitted to intensive care. Dummy variables are used for inpatient admission instead of actual number of days admitted for, in order to enable the model to be applied to data where numbers of days on a patient basis may not be available.

For all continuous variables, a curve is estimated (for log cost), to see whether a square, cubic or square root term is a better fit than the linear term.

Running the regressions⁴⁵

⁴⁵ Regressions were run using SPSS for Windows software version 9.0.

This section discusses the procedures for performing the regression analysis. While the nature of the variables being tested may suggest in advance the functional form or statistical tests required, some choices regarding analytic methods also have to be left until some preliminary regressions are run and the data examined.

First, the functional form chosen for testing was as ordinary least squares (OLS). Logistic regression analysis has been excluded, because the final model should do more than just predict whether a woman is high or low cost (according to an arbitrary cut-off point). Other models, such as Weibull or Cox, have been excluded because they are essentially survival models and not particularly appropriate here. Maximum likelihood estimator and generalised least squares models are compared to ensure the OLS is the best functional form for the data.

Second, the normality of the response variable (log cost or log log per pregnancy) is assessed using histograms. While it is recognised that the log transformation may reduce the problem of skewed data (thus ensuring the BLUE condition is met), outlying values are also examined in terms of their impact on the results. Dudley (1993) argued that the regression coefficients in OLS can be greatly affected by extreme high cost patients. Therefore, if log cost is still seriously positively skewed, and log log cost does not improve it, the bootstrap technique is applied to estimate the standard errors. While the bootstrap standard errors are likely to be similar to analytical ones if residual resampling is done, they are larger if casewise resampling is done. However, the practice of OLS suggests that minor deviations from normality do not matter. Log values to the base 10 are used in the base case analysis, and compared with log values to the base e to see if there is a better fit or if the distribution of the error term is better.

Third, the likely impact of the cluster design of the W.H.O. trial is assessed by comparing the variances of log cost per pregnancy for all the clusters. The variability of costs in the clusters (variability in cluster 1 / variability in cluster 2) is compared with the F distribution, to see if they vary in any meaningful way (at the 5% level). If there is significant variation, the regression model is run to take account of the cluster design.



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model are overstated. If important variables are omitted from the model, the F test will be significant. Also, there exists irrelevant variable bias, due to inclusion of irrelevant variables. This increases R^2 , despite having no real effect on Y. Finding specification error requires some judgement on the part of the analyst, and assessment of changes in results as variables are added to or removed from the regression equation. However, care is taken not to 'over fit' the model, which involves including variables that have limited relevance outside the study setting.

5.6 Cost prediction

Cost predictions are made in and between all countries (methods described below). Cost predictions are compared to cost observations and accuracy tabulated, using both relative (%) and US\$ values. Cost predictions are judged to be 'accurate' if the confidence intervals of predicted and observed costs overlap. Whether differences between predicted and observed cost are economically significant is judged based on whether the difference is more than the cost of one ANC visit.

5.6.1 The incremental cost impact method

As described in Chapter 4, the incremental cost impact method involves examining the required changes in current care to meet new guidelines, and identifying cost impact based on available local data. Where potential sizes of impact are identified, intervals are provided to reflect a judgement about the likely range of the impact. In applying the ICIM to identify the cost impact of the W.H.O. ANC programme, the following are examined:

- Impact on the timing and number of antenatal visits, and location of visits, based on W.H.O. recommendations and expected visit rate of women with adverse events.
- Impact on the content of visits, including risk assessment, health care provided, and advice and counselling. Information on the contents of the W.H.O. recommended programme are taken from the W.H.O. trial 'Manual of clinical activities', while information on the contents of current antenatal practices are taken from the clinic and patient baseline surveys.
- Impact on health service use. This takes into account differences in referral policy and scheduling of appointments as well as differences in morbidity rates. Also, assume that proportions of 'no treatment' rates for adverse events are identified earlier and treated under the W.H.O. ANC programme.

- Impact on unit cost. This takes into account differences in the resources required for the change in intervention, as well as possible changes in throughput.
- Impact on cost per pregnancy. This is evaluated by combining the two components of cost per pregnancy – health service use and unit cost – to estimate overall cost.

5.6.2 Regression analysis cost predictors

The basic methods for regression analysis used in this thesis have been described already. While cost prediction is done using the results of the MRA, other considerations must be taken into account, as well as further tests to see how well the model predicts. For example, if parameters are included that have limited relevance outside the data set that generated the coefficients, it may be wise to test the model with these omitted, or make adjustments to the model. Also, concern for a high R^2 should be balanced against the risks of including too many independent variables that add only marginally to the predictive power. Also, functional forms need to be decided in predicting cost. For example, the logistic and Cox models are better than ordinary least squares (OLS) at predicting the proportion of patients with high cost (given some arbitrary cut-off point). However, as Dudley (1993) argues, OLS is generally an accurate predictor of mean cost, and therefore where the main aim of cost prediction is to predict mean cost, as in this study, this is an appropriate functional form to use.

The implications of the results of the regression analyses for cost predictions are explored in detail. For example, whether the coefficients have similar signs and magnitude between countries is identified, and if not, reasons for differences are sought. Similarity between country would suggest some generalisability of results across countries, and therefore predictive power. This means that coefficients from the regression model can be useful in predicting changes in cost per pregnancy between populations of women and providers with different characteristics. However, if the magnitude of coefficients diverge, then causes are sought: are the model or data inadequate? or do different cost determinants exist between country?

5.6.3 Direct transfer method

The direct transfer method involves substituting cost per pregnancy in one country into another country, where the mean, median and confidence intervals are transferred using both nominal exchange rates and PPP.

5.6.4 Adjusted transfer method

Two main types of adjusted transfer of cost per pregnancy are used. These are:

1. Transferring average costs, but using local health service use rates. This involves assuming identical unit costs across countries, using both nominal exchange rates and purchasing power parities.
2. Transferring health service use rates, but using local unit costs. This involves assuming identical health service use rates across countries.

5.6.5 Simplified staff cost method

The simplified staff cost method for predicting average costs was described briefly in Chapter 4, and is based on the observation that the largest proportion of average costs are accounted for by staff costs^{46,47} (Barnum and Kutzin 1993). Therefore, the average contribution of staff costs to total direct costs for each country (X%) is used to predict total direct costs, by scaling up by $(1/X\%)/100$. Then the average contribution of direct costs to total costs for each country (Y%) is used to predict total health care costs, by scaling up by $(1/Y\%)/100$. This gives the equation:

$$UC_T = 1/X \times 1/Y \times UC_S$$

Where

- UC_T = Unit cost including costs of direct health care and overhead departments
- UC_S = Unit cost including only costs of direct staff (staff cost/throughput)
- X = (approximate % of direct health care costs that are staff costs)/100
- Y = (approximate % of total costs that are direct health care costs)/100

Therefore with UC_S , X and Y, UC_T can be predicted. The % values required for X and Y are taken as the average for each country, with upper and lower values reflecting the 95% confidence limits for each country. UC_S was estimated using data on the number of staff in the clinic or ward (N), average salaries for different types of staff (S), and monthly throughput data (T), using the following formula:

$$UC_S = \left[\sum_{i=1}^n N_i S_i \right] / T \quad \text{where } i = 1 \dots n \text{ reflects the number of staff categories}$$

⁴⁶ The exceptions are when health services are particularly drug/equipment intensive, or when imported goods are very expensive compared to non-traded goods such as staff.

⁴⁷ While this method was not found in the literature, the need for a quick costing method in Argentina and Saudi Arabia (for the W.H.O. antenatal care trial) requiring minimum data lead to the development of this technique of average cost prediction.

6 CAUSES OF VARIATION IN 'NATURAL' RESOURCE UNITS

The literature review concluded that to understand whether costs collected in one health care setting can be used to predict costs in other settings, the determinants of cost and the causes of cost variation should first be understood. The methods chapter argued that costs are more comparable between settings, particularly international settings, in their 'natural' units⁴⁸ – that is, before they are converted to monetary values. This is because of the problems associated with transferring monetary cost when it is unclear whether the prices used reflect opportunity cost and when there are alternative currency exchange methods to use, but uncertainty about which one is most appropriate for cross-country comparisons or generalisations. Also, an understanding of variation in natural units will contribute to the understanding of unit cost and cost per pregnancy variation in subsequent chapters. Therefore, this chapter identifies relative costs in natural units, tests for statistically significant differences, and examines the causes of inter-setting differences where they exist. Section 6.1 focuses on health service use, and Section 6.2 on resource use.

6.1 Causes of variation in health service use

6.1.1 Variation between trial arms

6.1.1.1 Size of variations

Tables 6.1 and 6.2 below show the average rates of health service use for women recruited to intervention and control arms in the W.H.O. antenatal care trial in Cuba and Thailand. Within country variation is the focus of this section, with a view to explaining why rates varied between arms (the control group and the intervention group).

Outpatient care

Table 6.1 shows that in Cuba the mean difference in ANC visits between trial arm is 5.6 visits, which is a statistically significant difference (a mean of 7.5 visits per woman in the intervention arm and 13.1 visits in the control arm). The 95% confidence interval of

⁴⁸ 'Natural' units are defined in this thesis to include both 'health service use' (numbers of visits, days or surgical case) and 'resource use' (amount of resource use per visit, day or surgical case).

difference between means is 5.47 to 5.8 visits⁴⁹. In Thailand the mean difference between trial arms in ANC visits of 2.7 visits is also a statistically significant difference (a mean of 4.4 visits per woman in the intervention arm and 7.1 visits in the control arm). The 95% confidence interval of difference between means is 2.58 to 2.88. Also, statistically significant difference in medians were found using the Wilcoxon rank sum test. Differences for both Cuba and Thailand are economically meaningful, in that the reduction in visits in the new programme is more than one in both countries.

Table 6.1: Outpatient antenatal care visits in Cuba and Thailand.

Country and trial arm	Outpatient antenatal care		
	Mean visits		Median visits
	Lower CL	Mean	
CUBA			
Average intervention	7.36	7.50	6
Average control	13.00	13.14	13
Difference	-	5.64	7
95% CI of difference	-	5.47-5.81	SIG ¹
THAILAND			
Intervention average	4.32	4.38	4
Control average	7.01	7.11	7
Difference	-	2.73	3
95% CI of difference	-	2.58-2.88	SIG ¹

¹ Statistically significant difference in medians were found using the Wilcoxon rank sum test; CI – confidence interval; CL – confidence limit.

Inpatient care

Table 6.2 shows rates of use of inpatient care in Cuba and Thailand. In general, rates of inpatient admission and lengths of inpatient stay in Cuba are higher in the intervention arm than the control arm: the average length of stay (ALOS) for high risk patients is 2.7 days longer in the intervention group (p<0.05). Rates of caesarean section are almost identical between trial arms in Cuba. Finally, there are similar rates of neonatal admission to intensive care in both arms, but the ALOS in the intervention group is on average 1.3 days longer (p>0.05).

In Thailand, there are no statistically significant differences between arm for inpatient ANC. For postpartum caesarean patients the ALOS is 0.73 days longer in the control group (p<0.05), and for vaginal delivery ALOS os 0.3 days longer in the control arm (p<0.05). Caesarean section rates are 1.9 percentage points higher in the intervention

⁴⁹ Although this confidence interval, using independent samples t test, does not reflect the skewed nature of the data (see Appendix 5 Figure 5.1), the difference is large enough to be confident that a statistically significant difference exists.

arm (7.3% versus 5.4%, $p<0.05$), and a higher proportion of babies are admitted in the intervention arm (4.4% versus 3.2%, $p<0.05$). The next section explores why these statistically significant differences might have occurred.

Table 6.2: Inpatient health service use in study countries.

Country and trial arm	Inpatient ANC				Deliveries		Postpartum stay		Neonatal ICU	
	% admissions		ALOS (days)		% distribution		ALOS (days)		% admissions	ALOS (days)
	LR	HR	LR	HR	VD	CS	VD	CS		
CUBA										
Int. arm av.	10.6%	4.1%	13.6	11.0	77.4%	22.7%	3.22	6.03	5.38%	12.00
Cont. arm av.	10.0%	3.2%	13.1	8.3	76.6%	23.2%	3.07	5.82	6.25%	10.68
Difference	-0.6%	-0.9%	-0.5	-2.7	-0.8%	+0.5%	-0.15	-0.21	0.87%	-1.32
95% CI of diff.	NS	NS	NS	-5.2--0.1	NS ¹		-0.36-0.4	-0.6-0.2	NS ²	-3.7-1.2
THAILAND	ALL									
Int. arm av.	2.8%		2.9		92.7%	7.3%	1.79	2.26	4.4%	6.66
Cont. arm av.	2.6%		3.2		94.6%	5.4%	1.49	2.99	3.2%	7.44
Difference	0.2%		0.3		-1.9%	+1.9%	-0.3	0.73	1.2%	0.78
95% CI of diff.	NS		-0.5-1.2		SIG ³		-0.34--0.24	0.34-1.1	SIG ⁴	-2.8-4.3

Table key: ALOS = Average length of stay; ICU = intensive care unit; LR = low risk; HR = high risk; VD = vaginal delivery; CS = caesarean section; NS = Not statistically different; SIG = Statistically different; ANC – antenatal care.

¹ The difference of 0.5% between the control and intervention arms for CS rate was not found to be statistically different at $p=0.05$, using the chi-squared test.

² The difference of 0.87% between the control and intervention arms for neonatal admission in Cuba was not found to be statistically different at $p=0.05$, using the chi-squared test.

³ The difference of 1.9% between the control and intervention arms for CS rate was found to be statistically different at $p=0.05$, using the chi-squared test.

⁴ The difference of 1.2% between the control and intervention arms for neonatal admission in Thailand was found to be statistically different at $p=0.05$, using the chi-squared test.

6.1.1.2 Causes of variations

Outpatient care

The first and possibly most important health service use difference to explain is the reduction in antenatal visits due to the ‘intervention’ in both Cuba and Thailand. As described in the methods chapter, the intervention recommended a 4 visit minimum for low risk women, and further visits if indicated. This rate is almost reached (in terms of the average) in Thailand (4.4 visit average) and there is a substantial reduction in Cuba (to a 7.8 visit average). The trial Steering Committee is in agreement that the principal reason for this reduction was the successful implementation of the W.H.O. programme of antenatal care. The main evidence supporting this conclusion is that the reduction was experienced in intervention clinics but not in control clinics, supported by the baselines surveys that showed clinics to have similar characteristics, including average visit rates (Piaggio et al 1998).

Appendix 5 Table 5.1 suggests other possible factors explaining why ANC visit rates varied between intervention and control arms. These factors implicitly raise questions

over the success of the matching of clinics in the cluster design of the trial, and whether minor (random) differences were in fact responsible for differences observed in trial outcomes. While most of these factors were found to vary insignificantly between arms, some factors were found to vary. In Cuba, these included:

- The medicine cost per visit to women was higher in the control group. This would have a disincentive effect on attending health care in the control arm.
- Before the trial, women were expected to be concerned about receiving less visits in the W.H.O. ANC programme. However, the satisfaction survey results showed that more women in the intervention group in Cuba said they were happy with the antenatal care they received than in the control group (93% versus 87%).
- Syphilis tests were done on the spot in the intervention polyclinics, meaning that patients did not have to come back again for the results and treatment.
- Some risks and morbidity rates were different between arm. These are shown in Appendix 5 Table 5.2. Risk differences included higher rates of hospital admission for hypertension in the last pregnancy (3% versus 1%) and higher rates of previous reproductive tract surgery (4% versus 1%) in the intervention group. More women were referred in the intervention arm (15% versus 12%).

In Thailand, some other differences were observed between control and intervention arms, summarised in Appendix 5 Table 5.1:

- The travel method differed marginally, suggesting that women in the control arm were slightly more mobile because a larger proportion used private motorbike to attend ANC - 15% more women than in the intervention arm. Despite this, mean travel time and travel cost were identical between arms.
- Waiting and treatment times in control clinics were 32 minutes longer than in the intervention arm (98 minutes versus 66 minutes mean), thus acting as a disincentive for women to attend ANC in the control arm.
- Cost per visit incurred by women for medications was on average 20 Baht higher in the control arm, but nutritional supplements were 16 Baht higher in the intervention arm, thus balancing the cost difference.
- Lost earnings per woman were 30 Baht higher in intervention arm (for those women losing income). This was not because they earned more, per se, but because only 22 women lost income in the control arm versus 37 women in the intervention arm.

- Satisfaction with spacing of visits in the new programme was lower (66% versus 85%) as well as satisfaction with the number of visits (72% versus 90%). However, when asked about overall satisfaction with the service, the groups were more equal (95.5% versus 97.5%).
- More women attended ANC early in the control group (32% versus 38% reported by 12 weeks, and 53% versus 63% by 16 weeks), thus possibly leading to more visits.
- Bleeding during pregnancy was more commonly reported in the intervention arm (103 versus 35 women) and more women were treated for urinary tract infection (56 versus 28 women).

These results from Cuba and Thailand show mixed evidence to explain why ANC visits were higher in the control arms. Several of these factors may have influenced the average numbers of visits in each trial arm, and but these data do not allow a quantitative link to be drawn between each individual factor and the number of ANC visits.

Inpatient and delivery care

Although the W.H.O. antenatal care programme did not provide guidelines for management of inpatients, some differences were observed. Table 6.2 showed that inpatient admission rates were not significantly different between arm, but that average length of stay did vary significantly between trial arms for high risk admissions in Cuba and for postpartum stay in Thailand.

Although statistically non-significant, women in the intervention group in Cuba were referred for higher level care more often (14.6% versus 12.5%), leading to a higher admission rate (15.2% versus 12.8%). The higher admission rate was due to more cases of the following: 11 pre-eclampsia, 10 prelabour rupture of membranes (PROM), 12 malpresentation, 11 multiple gestation, 5 urinary tract infection (UTI), 8 cardiac disease, and 8 vaginal bleeding. Most of these differences are unlikely to be caused by quality differences between antenatal care programmes. The higher rates of admission during pregnancy and neonatal admission and CS rate in the intervention arm in Thailand may have been the result of chance. On the other hand, they may have been caused by the providers practising the new programme were (a) more efficient in diagnosing

conditions, and/or (b) more risk averse. However, these factors were not measured to explain variation.

Admission rates and length of stay were higher in the intervention arm than the control arm in Cuba for postpartum care and for neonatal intensive care ALOS. However, these differences are not explainable using data on maternal and neonatal delivery outcomes from the trial data set⁵⁰. Finally, a higher proportion of neonates were admitted to the intensive care unit (ICU) in the intervention arm in Thailand (4.4% versus 3.2%, $p<0.05$), although they had a lower ALOS in the intervention arm. This may have been due to non-significantly higher rates of morbidity and CS in the intervention arm, thus affecting the neonate's condition.

A general problem faced in this study in trying to explain different rates of admission and length of stay between trial arms is that there are a wide range of pregnancy events and outcomes, but these have not been captured on a generic case-mix scale. Therefore ill health, and its' link to hospital admission and length of stay, could not be compared more exactly between trial arms. In addition, while the randomisation of clusters should have provided trial arms with well matched background (a priori) characteristics, it is possible that there still existed some random differences between arms, thus causing significant differences in some outcomes that were not related to the intervention under study. This point can be illustrated using anecdotal evidence, such as in the case of Si Chompoo hospital (control arm, Thailand) which had a policy of discharging normal vaginal deliveries on the same day as delivery, thus helping explain the lower postpartum ALOS in the control arm. This example provides further rationale for examining health service use at the individual health facility level, discussed in the next section.

6.1.2 Variation between individual health facilities

Table 6.3 below shows health service use data at the individual health facility level, as well as showing aggregated rates by trial arm and by country (Appendix 5 Table 5.4 shows a more complete version of this table, with median values and numbers of cases).

⁵⁰ Rates of low birth weight were the same across trial arms; adverse diagnosis at delivery was higher in the intervention arm (16% versus 13%).

The results show some rates to be very similar between health facilities, but show other rates to be disparate between health facilities, requiring further examination.

Table 6.3: Health service use data by health facility, trial arm, and country.

Country and health care provider	Outpatient ANC		Inpatient ANC			Deliveries		Postpartum		Neonatal ICU	
	Average visits		ALOS (days)			Percentage		ALOS (days)		ALOS (days)	
	Mean	Median	LR	HR	ALL	VD	CS	VD	CS	Mean	ALL
CUBA											
13 de Marzo	7.5	6	16.3	10.5	2.22	77	23	3.0	6.8	11.5	0.61
Albarran	7.8	6	10.6	14.0	1.81	82	18	3.3	5.5	14.4	0.69
Galvan	7.3	5	17.3	9.5	2.56	74	26	3.8	6.3	13.8	1.17
Manduley	7.6	5	12.2	11.7	1.76	75	25	2.9	5.7	10.4	0.49
Romay	7.4	5	15.6	11.3	2.15	76	24	3.1	6.2	12.6	0.75
Zuluetta	7.3	5	10.1	5.9	1.24	79	21	3.3	5.6	7.7	0.42
<i>Av. intervention</i>	<i>7.50</i>	<i>6</i>	<i>13.61</i>	<i>10.92</i>	<i>1.95</i>	<i>77.4</i>	<i>22.6</i>	<i>3.22</i>	<i>6.03</i>	<i>12.0</i>	<i>0.7</i>
Aballi	13.3	13	14.9	7.1	1.77	77	23	3.1	6.0	9.8	0.55
Escalona	13.0	12	15.0	6.7	1.93	76	24	3.2	5.7	11.0	0.81
Guiteras	12.4	12	14.1	8.7	0.94	79	21	3.3	5.2	9.6	0.65
Reina	13.0	13	11.3	11.7	1.32	76	24	2.9	5.5	10.1	0.42
Tamayo	13.6	13	8.5	8.4	1.06	77	23	2.9	6.0	14.1	0.76
Vantroi	13.1	13	13.3	8.0	1.50	77	23	3.1	6.4	10.2	0.65
<i>Average control</i>	<i>13.14</i>	<i>13</i>	<i>13.07</i>	<i>8.25</i>	<i>1.53</i>	<i>76.6</i>	<i>23.4</i>	<i>3.04</i>	<i>5.82</i>	<i>10.68</i>	<i>0.6</i>
AVERAGE ALL	10.23	12	13.31	9.65	1.75	77.0	23.0	3.15	5.92	11.27	0.66
THAILAND											
Chumpae	4.05	4	2.5	0.075		94	6	2.11	3.96	4.79	0.30
Banphai	4.58	4	2.0	0.019		91	9	1.79	3.83	11.89	0.59
Phuwiang	4.74	4	3.4	0.086		87	3	1.40	2.26	7.88	0.11
Manjakiri	4.43	4	2.9	0.099		95	5	1.53	2.48	3.94	0.13
Khaosuankwang	4.24	4	4.0	0.157		97	3	1.69	2.05	2.78	0.08
Waeng Noi	4.47	4	2.3	0.087		95	5	1.95	1.53	6.17	0.18
<i>Av. intervention</i>	<i>4.38</i>	<i>4</i>	<i>2.87</i>	<i>.073</i>		<i>93.0</i>	<i>7.0</i>	<i>1.78</i>	<i>3.00</i>	<i>7.44</i>	<i>0.28</i>
Kranuan	6.56	7	3.4	0.141		93	7	1.50	4.95	5.16	0.12
Nongsonghong	6.19	6	1.8	0.022		96	4	1.73	3.32	5.14	0.33
Phol	8.11	8	4.2	0.106		93	7	1.92	3.70	12.68	0.50
Nongrua	6.37	6	2.0	0.010		95	5	1.43	4.65	3.40	0.13
Srichompoo	7.10	7	3.0	0.005		98	2	1.03	0.23	6.75	0.09
Nampong	8.42	9	2.6	0.193		93	7	1.49	2.85	8.94	0.50
<i>Control average</i>	<i>7.11</i>	<i>7</i>	<i>3.19</i>	<i>0.085</i>		<i>95.0</i>	<i>5.0</i>	<i>1.64</i>	<i>2.26</i>	<i>6.60</i>	<i>0.25</i>
AVERAGE ALL	5.71	5	3.02	0.080		94.0	6.0	1.64	2.61	7.02	0.27
SOUTH AFRICA											
Prince Mshiyeni	5.97	6	6.9	2.330		0.78	0.22	2.21	7.33	3.13	1.69

TABLE KEY: ANC – antenatal care; LOS – length of stay; HR – high risk woman; LR – low risk woman; VD – vaginal delivery; CS – caesarean section; med. – median; ALL – all cases.

Outpatient care

Outpatient antenatal care, in general, shows consistency between health facilities within the same trial arm. This can be seen in column 3 of Table 6.3, where ANC visits in the intervention arms varies between 7.3 (Galvan) and 7.8 (Albarran) visits per woman in Cuba, and between 4.05 (Chumpae) and 4.74 (Puvieng) in Thailand. In the control arm, there is slightly greater variability, between 12.4 (Guiteras) and 13.6 (Tamayo) visits per woman in Cuba, and between 6.19 (Nongsonghong) and 8.42 (Nampong) in Thailand. This is likely to be because there was less standardisation of ANC procedures in control than intervention hospitals. While it is useful to be able to identify causes of variation between health facilities, there are limited variations in women's characteristics between Nongsonghong and Nampong district hospitals in Thailand (see Appendix 5 Table 5.3). However, previous inpatient admission and previous low birth weight rates were higher in Nampong than the average, suggesting that case-mix may have been heavier there, thus leading to more visits. However, there were few other factors explaining why ANC visit rates varied across clinics.

In terms of other factors determining numbers of ANC visits, the data on factors listed in Appendix 5 Table 5.1 are not able to show variation between individual health facilities, due to small sample sizes (around 30 per facility).

Inpatient care

Inpatient admission and length of stay during pregnancy varied between health facilities in both Cuba and Thailand, with rates in some health facilities several times those of other health facilities (see Table 6.3). In Cuba for example, Guiteras had a third the number of inpatient days per trial woman compared with Galvan. Table 6.3 also shows that Tamayo had a low rate, and 13 de Marzo and Romay had high rates. The rate of referral partly explains these rates, with 7.3% of women referred in Guiteras, and around 16% of women in Galvan and 13 de Marzo, compared with the Cuban average of 13.6%. In general, clinics with high inpatient days (IPD) per woman had higher risk status at the start of pregnancy, but there were similar rates of pregnancy events in all clinics.

In Thailand, Nongrua and Sichompoo had by far the lowest average number of inpatient days, well under one tenth the rates of recorded in Khaosangkuang and Nampong. High IPD rates can be partly explained through a high referral rate in Nampong (11% of women), and significantly higher sexually transmitted disease treatment rates, urinary tract infection cases and bleeding rates in both Khaosangkuang and Nampong. Also, there were no referrals in Nongrua (out of 400 women) and only 1 referral in Si Chompoo (out of 595 women).

Although the CS rate in Cuba was almost identical between trial arm, it ranges from 18.4% in Albarran to 25.7% in Galvan (a statistically significant difference using chi-squared test, $p < 0.05$). In Thailand, the CS rate ranged from 2% in Sichompoo to 12.6% in Puvieng (also a statistically significant difference). This large variation in Thailand is mainly due to differences in cephalo-pelvic disproportion, previous CS, breech position, failure to progress, and fetal distress. The results suggest that hospitals manage labour differently, although practices were not studied in detail to support such an assertion.

The postpartum ALOS per woman were similar between policlinics in Cuba, but in Thailand ALOS ranged from 1.0 in Sichompoo to 2.1 in Chumpae following vaginal delivery, and from 0.23 in Sichompoo⁵¹ to 5.0 in Kranuan following CS. Sichompoo had such low rates due to a policy to discharge women as quickly as possible following delivery. The trial data set provided no detailed information on health states of women following delivery (except alive/dead), and therefore causes of variation cannot be examined further.

Intensive care days per neonate ranged from 0.42 in Zulueta to 1.17 in Galvan ($p < 0.05$). The low days per neonate in Zulueta were not due to a low admission rate, but because ALOS was low at 7.7 days compared to the country average of 11.3 days. Galvan, on the other hand, had both a high admission rate and a high ALOS (13.8 days per admission). The LBW rate was high in both Zulueta and Galvan; therefore these 2-way comparisons do not explain why days per neonate are low in Zulueta. In Thailand, days per neonate ranged from 0.08 in Khaosankuang to 0.59 in Banphai ($p < 0.05$). The low days per neonate in Khaosankuang were partly due to a low admission rate compared to other hospitals, as well as a low ALOS per admission. Likewise, days per neonate were

high in Banphai, Phon and Nampong due to a higher ALOS per admission, and a high admission rate. The LBW rate was similar across hospitals, although it is low in Nongrua and high in Manjakiri and Waengnoi. In conclusion, it appears that the measures of case-mix do not predict ALOS. On the other hand, as already mentioned, the availability of neonatal intensive care facilities varied between hospital.

6.1.3 Variation between countries

Outpatient care

Visits per woman in the intervention arm range from 4.4 in Thailand to 7.5 in Cuba, and in the control arm from 5.97 in South Africa, to 7.1 in Thailand, to 13.1 in Cuba. Table 6.4 lists the same factors as those in Appendix 5 Table 5.1, at the country level, to examine whether they could explain differences in numbers of antenatal visit between countries. Several reasons are discernible from Table 6.4 why women in Cuba may receive more ANC visits than other countries. These include the fact that services are more convenient to attend, they have shorter waiting times in the clinics and paid leave from employment, there are generally less cultural barriers to modern health services, and women have been educated for longer. Also, there are no private alternatives to the public health system in Cuba. Data from Appendix 5 Tables 5.2 and 5.3 show that women in Cuba have higher risk status, from previous pregnancies and abortions.

Attendance rates may be below the recommended 10-12 visits during pregnancy in South Africa because health services are not highly accessible geographically, and because clinics are always very crowded and women have to wait many hours before and during care. Also, women in South Africa may be more constrained than the other countries by whether her partner, husband or their family allows her to attend ANC.

On the other hand, rates of illness episode are lower in Cuba than Thailand and South Africa. Appendix 5 Tables 5.2 and 5.3 show that case-mix variables vary significantly between country for both risk factors and events during pregnancy, some of which determine health service use (through more antenatal visits and inpatient admissions). For example, a higher proportion of women in Cuba have previous abortions and negative previous birth outcomes (partly due to higher parity), leading to higher risk status, and thus more antenatal visits and higher CS rate. Also, the fact that women

⁵¹ This rate is from a very small sample size.

reported the earliest in pregnancy in Cuba partly explains the high average number of visits there. On the other hand, previous surgery on reproductive tract (15%), last baby low birth weight (LBW) (24.4%) and hypertensive diseases of pregnancy (11%) are all high in South Africa, where women receive an average of only 6 antenatal visits. However, the late reporting of women in South Africa (80% not attended by the 20th week) is likely to account for their low rate.

Table 6.4: Assessment of factors explaining health service use variation between country.

Determinants of health service use	Data available on factors being compared	Cuba	Thailand	South Africa
Patient factors				
Accessibility	Average distance from the clinic Average time from the clinic Availability or use of transport Average cost of transport	< 1 km 5-10 minutes Walkable 1.4 Peso return	0-20 km 30-35 minutes Bus & motorbike 28 Baht return	0-20 km 30 minutes Taxi or by foot R3.0 return
Cost of health services	Cost of consultation Cost of medicines Cost of items advised Relative cost to wage rate	0.7 Peso (gift) 3 Peso / visit Extra food 2% month wage	Zero 85 Baht / visit 60 Baht / visit 1% month wage	Zero R1.4 / visit R2.9 / visit 0.8% month wage
Opportunity cost	Waiting and treatment time Proportion of women with jobs Time taken off work Paid leave to attend ANC Average salary	40-80 minutes 14% paid 2 hours Yes 200 Peso / m	60-100 minutes 21% paid Half day If formal job 14 Baht / hour	120-180 minutes 10% paid Half day No R566 / month
Use of alternative services	Alternatives available Amount of use of alternatives	Healer Minimal	Healer, private Small %	Healer, private 50% of women
Familiarity with modern health care	% first pregnancies Baseline average ANC visits % institutional delivery rates	18.5% 13-15 100%	40.9% 7-9 95%	35.8% 4-6 60%
Quality of care	% of women happy with service % women happy with spacing	90% 87%	96.5% 76%	n/a n/a
Socio-economic status	Average age % not in stable union/marriage Number of years of education Average rooms per house Average people per house	26.2 9.9% 11.6 years 2.3 rooms 4.8 people	24.5 1.1% 6.5 years 2.6 rooms 5.2 people	25.5 84.6% n/a n/a n/a
Cultural attitudes To services	Cultural acceptability of services Need permission from family	Accepted No	Accepted Some	Accepted If 'lebola' paid ¹
Attitudes to risk	Desire for minimum ANC visits	Yes	Yes	Not available
Actual risk levels	Country-specific risk factors	Abortion, CS and previous surgery	Thalassemia	Hypertension
Other	Weather patterns	Heat and rain	Heat and rain	Not a barrier
Provider factors				
Financial incentives To providers	Fee schedule Other payments to providers	None Sometime gift	None Sometimes gift	None None
Compliance with standards of care	General contents of ANC Monitoring systems in place	Western model Health targets	Western model Supervision	Western model Supervision
Quality or effectiveness of health care staff	Training level of main providers Availability of diagnostic equip. On-going refresher courses	Obstetricians In policlinics Yes	Midwives In hospitals Yes	Midwives Not laboratory Yes
Capacity use	Average % of capacity used	Variable	Variable	Always very busy

¹ Lebola is the payment made by the woman's family to her partner's family for the marriage. After payment, she is more likely to have her ANC paid for by the family.

Inpatient care

Average inpatient days per woman in the trial ranged from 0.08 in Thailand to 1.75 in Cuba. From the survey in South Africa the rate was 2.33 days per woman. As already discussed above, the event rates in South Africa were higher than the other countries, possibly explaining why 32% of women were admitted to hospital during pregnancy. For example, hypertensive diseases of pregnancy were the primary reason for admission in a high proportion admissions in South Africa (10.8% of women had hypertensive diseases of pregnancy)⁵². However, the 22-fold difference in IPD per trial woman between Cuba and Thailand could not be explained using case-mix comparisons. Possible causes were the high rates of bleeding suffered by women in Cuba (40% compared to only 2.2% in Thailand)⁵³, as well as higher rates for pregnancy-induced hypertension, pre-eclampsia, uterine height low for gestational age, premature rupture of membranes, malpresentation, and renal disease. The significantly higher ALOS in Cuba suggests that the severity of conditions could have been worse there, although there was noticeable variation in hospital discharge policy as case-mix differences do not account for differences in ALOS. As was suggested by the high number of ANC visits, and the national focus on maternity care in Cuba, health care was provided more intensively in Cuba than the other countries, and this is likely to have accounted for a large proportion of the difference in mean inpatient stay per trial woman compared to Thailand.

Cesarean section rates varied from 6.4% in Thailand to 22.3% in South Africa to 22.9% in Cuba. Differences in CS rates were due to practice style variations as well as case-mix variations. Practice style variations were suggested by the very different intrapartum rates, suggesting that health care providers had different attitudes to risk. Cuba is typical of most Latin American countries, where CS rates are high, whereas South Africa (and possibly this study in South Africa) is unusual in that CS rates in Africa are generally low. CS rates should be interpreted with the level of health facilities of the samples in mind: in Cuba and South Africa health facilities were secondary level, and in Thailand they were primary level. This is a potentially important determinant of CS rate, because the availability of a well equipped specialist maternity operating theatre is likely

⁵² However, these data from South Africa should be interpreted based on the fact that the sample was hospital-based, meaning that the rates did not represent the population rates in Umlazi.

⁵³ This difference may be due to difference in definitions of bleeding, despite attempts made in the ANC trial tried to standardise definitions.

to affect the doctors use of CS. Also, four of the sample hospitals in Thailand did not perform CS, thus reducing rates there.

Case-mix is also an important determinant of CS rates, although again there is limited data to conclude how important. For example, higher parity in Cuba meant that that women were more likely to require CS (such as previous CS). In South Africa there was a high incidence of fetal distress, although it is unclear why. It may have been due to better diagnostic instruments, or due to risk aversity of doctors and nurses.

Postpartum ALOS ranged from 1.8 in Thailand to 3.3 in South Africa to 3.8 in Cuba (significant difference between Cuba and South Africa compared to Thailand). Higher CS rates in Cuba and South Africa probably caused part of the higher postpartum ALOS in those countries. Post-CS ALOS was lowest in Thailand (2.6 days), followed by Cuba (5.9 days) and South Africa (7.3 days). Thailand has an average post-vaginal delivery stay of 1.6 days, half that of Cuba's. This is likely to reflect differences in practice style than differences in case-mix.

Neonatal ALOS for the whole study population ranged from 0.27 in Thailand to 0.66 in Cuba to 1.58 in South Africa ($p < 0.05$). Neonatal admission rates were 5.8% in Cuba, 3.8% in Thailand, and 71% in South Africa. The rate was so high in South Africa, because the 'nursery' in Prince Mshiyeni hospital where most newborns are taken is both a high risk and low risk area. Also, there is a lower average Apgar score at five minutes after birth in South Africa. A score of 10 was achieved by 76% of neonates, compared to 92% in Thailand and 96% in Cuba. In Thailand, district hospitals did not have a separate neonatal ward, but the incubators and cots were usually kept in the female inpatient ward. The difference in facilities perhaps suggests why in Cuba 78% of LBW babies were admitted, compared with 21% in Thailand. Also, neonates were more likely to be admitted following CS, with 8.6% of neonates in Cuba being admitted after CS compared to 4.6% after vaginal delivery; 12.4% versus 3.08% in Thailand, and 90.4% versus 49.2% in South Africa.

Cuba had the highest neonatal ALOS for admitted babies at 11.3 days, 4.3 days more than Thailand, and 9 days more than South Africa. The ALOS is lowest in South Africa

due to the better average case-mix there. Again, these differences reflected differences in practice style more than differences in health status of the neonates. However, except for the Apgar score discussed above, there are limited data on the condition of the neonate to explain these differences further.

6.1.4 Conclusions

The above analyses have found that several factors were responsible for variations in health service use during pregnancy and delivery, both within and between countries. The analyses have benefited from detailed case-mix and health service use data from the ANC trial for large samples of women, and these were supplemented by data on the costs to women of attending ANC. Several conclusions are made.

First, the trial arm of women was the most important determinant of numbers of antenatal visits. However, for other types of care, health service use was more dependent on which provider she attended, rather than which trial arm she was in. Second, proximity to health services was a potentially important determinant of health service use, as suggested by the higher rates in Cuba; however, there are other factors confounding this comparison. Third, case-mix in the form of risk factors and event rates probably determined health service use, and explained some variation between health facilities within country, as well as differences between countries. Fourth, patient expense and opportunity cost were a likely determinant of health service use, although a detailed study was not done of the disincentive effect of time costs and official or unofficial user fees. Fifth, practice style such as risk aversity and medical training was probably an important determinant of health service use, as many variations could not be explained by other factors. Practice style variations were likely to occur both within and between countries. The implication of these findings for generalisability is that, even when implementing a standardised programme in more than one country, health service use cannot be predicted without knowledge of local practices and populations, such as compliance with national guidelines, risk aversity of health care staff and women, availability of both primary and referral services, and case-mix.

6.2 Causes of variation in resource use

The aim of this section is to examine what factors are responsible for the different rates of resource use between trial arm, health care providers, and country. Resources are

examined in terms of both their availability and their productivity. Categories of resource examined include staff, equipment, drugs, materials, utilities and buildings. Each resource is examined in turn, before the last section brings the results together.

6.2.1 Staff

Description of staffing patterns

Appendix 6 Tables 6.1 to 6.4 provide summaries of staffing patterns in participating health facilities, broken down by relevant department or cost centre, and by staff types, with input/output ratios. Appendix 6 Table 6.1 shows that there are between 153 and 340 staff in the sample policlinics in Cuba. About a third or a half of these staff work in the family doctor clinics (FDC), most of which are separate buildings from the policlinics within the community. In each FDC there are usually two doctors and two nurses, thus giving an average doctor/nurse ratio of 1.05, although this varies between policlinics from 0.52 to 2.03. The rest of the policlinic staff either work in specialist clinics (33%) or in support departments (7.2%) inside the policlinic building. All services are outpatient in nature, although many specialists also do shift work in hospitals.

Appendix 6 Table 6.2 shows that district hospitals in Thailand employ between 72 and 224 staff, divided between inpatient, surgical, outpatient and support services. There are no specialists in these hospitals, and the number of doctors varies between 1 and 6 per hospital (of whom one is always the hospital director), and an average of 10 nurses for every doctor. ANC is usually restricted to 1-2 days per week, and is provided in the health promotion section of the outpatient department. The majority of ANC is provided by nurses. Appendix 6 Table 6.3 shows that sample health centres in South Africa are mainly staffed by nurses, with a few non-technical support staff, totalling between 27 and 40 staff. There are no doctors in the health centres. Most administrative work is done by the nurses, although finances and services are controlled by the Community Care department in the hospital. ANC is usually restricted to 2 days per week, when several nurses are involved in ANC activities.

Finally, data are provided in Appendix 6 Table 6.4 on staffing patterns in referral hospitals in Cuba and South Africa. In Cuba, all health care in America Arias is provided by obstetricians or gynaecologists (as it is a maternity hospital) and nurses, and over 50% of the hospital staff are working in supportive activities (administration,

laboratory, pharmacy, laundry, etc). In South Africa, inpatient wards are staffed mainly by nurses, hence the lower proportion of medical doctors than in Cuba where there are about 8 nurses per doctor.

Staff output ratios

In this section the reader is referred again to the tables in Appendix 6, but graphical summaries are presented in the text below. Figure 6.1 shows that the number of ANC visits per full-time equivalent worker (in direct health care activities) varies between polyclinics in Cuba, between 66 visits per staff per month in 13 de Marzo to 157 in Vantroi, with an overall polyclinic average of 89. 13 de Marzo and Vantroi have similar numbers of staff in family doctor clinics, but the throughput of patients is more than double in Vantroi. The cause of this difference does not appear to be due to much higher occupancy rates in 13 de Marzo, as shown in Figure 6.1.

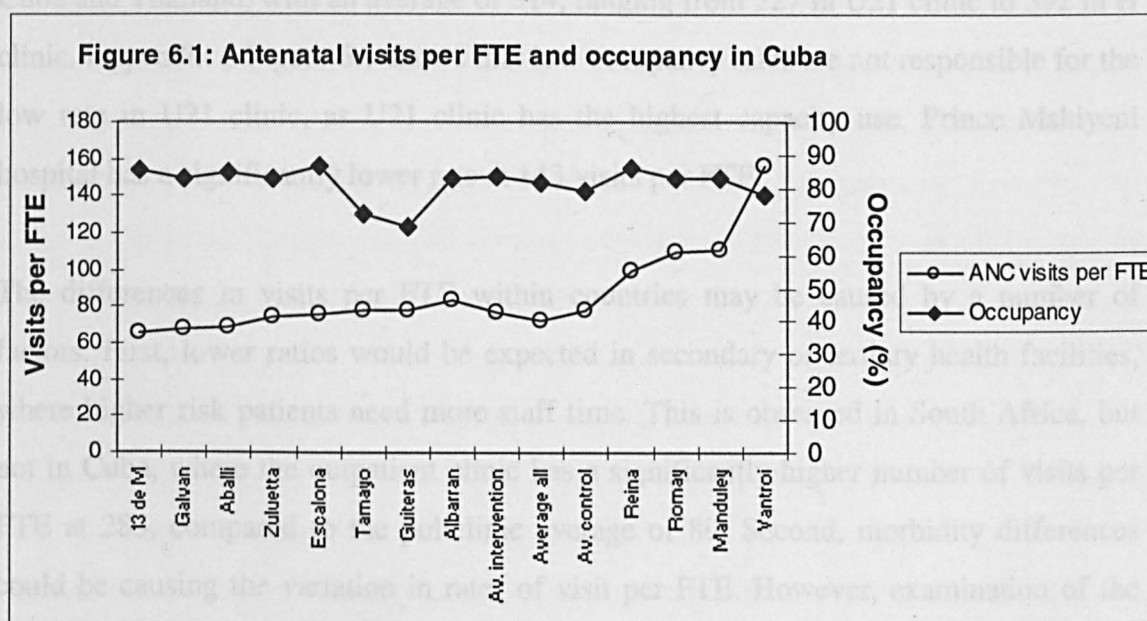
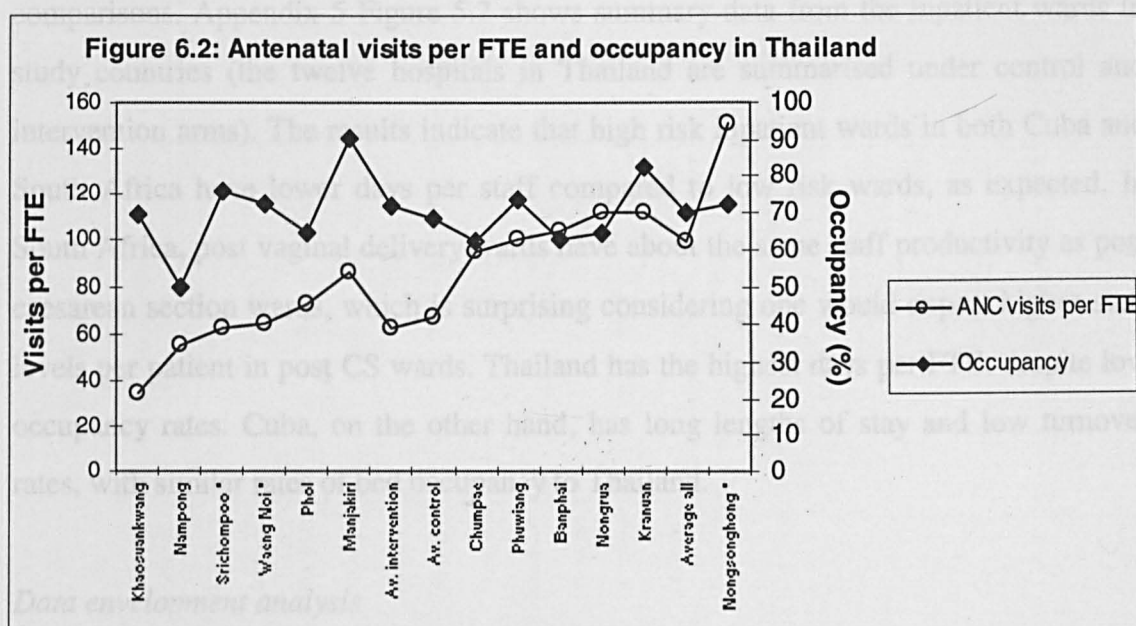


Figure 6.2 shows that the number of ANC visits per full-time equivalent worker (in direct health care activities) also varies significantly between hospitals in Thailand, between 34 visits per staff per month in Khaosankuang to 151 in Nongsonghong. Khaosankuang is the smallest hospital in the sample, but has a relatively large number of non-medical staff working in the health promotion unit, which may partly explain the low rate. Most hospitals have rates in the 60-120 range, with an average of 87 visits per staff member per month, which is similar to Cuba (89). Also, staff productivity is an average 15% lower in intervention hospitals, possibly due to less ANC visits.



Finally, in South Africa the ANC visits per staff member are much higher than those in Cuba and Thailand, with an average of 314, ranging from 227 in U21 clinic to 392 in H clinic. Appendix 6 Figure 6.1 shows that low occupancy rates are not responsible for the low rate in U21 clinic, as U21 clinic has the highest capacity use. Prince Mshiyeni hospital has a significantly lower rate at 143 visits per FTE.

The differences in visits per FTE within countries may be caused by a number of factors. First, lower ratios would be expected in secondary or tertiary health facilities, where higher risk patients need more staff time. This is observed in South Africa, but not in Cuba, where the outpatient clinic has a significantly higher number of visits per FTE at 283, compared to the polyclinic average of 89. Second, morbidity differences could be causing the variation in rates of visit per FTE. However, examination of the data shown in Appendix 5 Tables 5.2 and 5.3 demonstrated that there are limited differences in morbidity levels between health facilities in both Cuba and Thailand. Between country there are greater differences in morbidity rates, although South Africa, the higher morbidity population, also has the highest staff productivity.

Staffing patterns are also examined below for inpatient care. While there are unlikely to be systematic differences between trial arms (as the new programme only changes the way outpatient care is provided), it is useful to examine relative rates of staff productivity in order to understand unit costs later, and also it allows cross-country

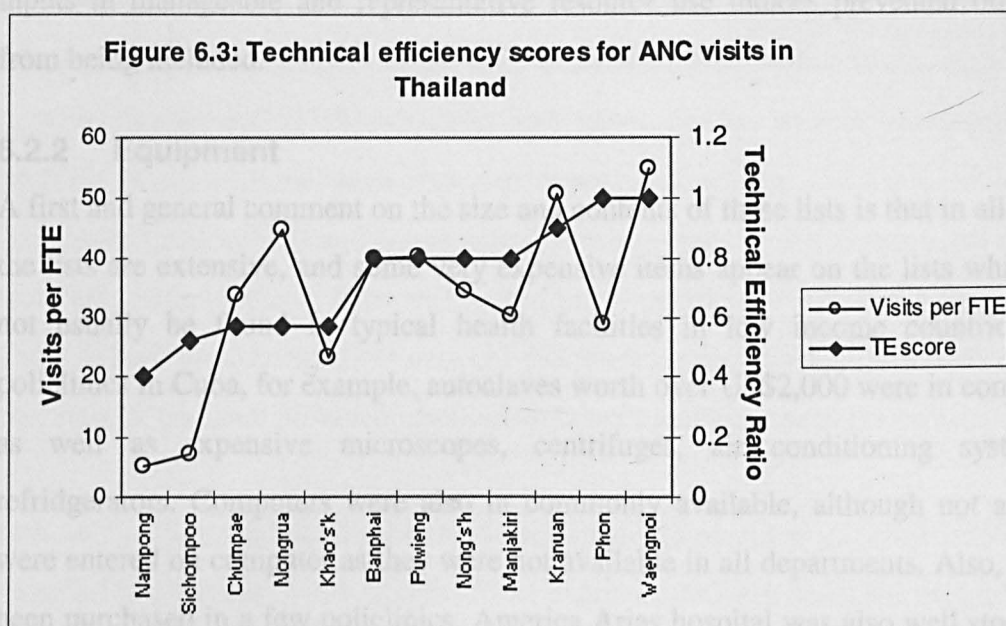
comparisons. Appendix 5 Figure 5.2 shows summary data from the inpatient wards in study countries (the twelve hospitals in Thailand are summarised under control and intervention arms). The results indicate that high risk inpatient wards in both Cuba and South Africa have lower days per staff compared to low risk wards, as expected. In South Africa, post vaginal delivery wards have about the same staff productivity as post caesarean section wards, which is surprising considering one would expect higher staff levels per patient in post CS wards. Thailand has the highest days per FTE, despite low occupancy rates. Cuba, on the other hand, has long lengths of stay and low turnover rates, with similar rates of bed occupancy to Thailand.

Data envelopment analysis

The final analysis with regard to staff is the use of data envelopment analysis (DEA) to calculate technical efficiency scores, using staff numbers and building space as inputs. In Cuba, Vantroi and Guiteras policlinics are the most efficient from the model, both obtaining a TE score of 1.0. Four policlinics score around 0.6 (see Appendix 7 Figure 7.1). The Pearson correlation coefficient of 0.37 between visits per FTE and the TE score suggest that they are not highly correlated in Cuba. Differences between the two ratios in Guiteras, Tamayo and Galvan suggest that these policlinics make better use of their building space compared to other policlinics.

In Thailand, there was greater variation in the TE score than in Cuba, between 0.4 for Nampong and 1.0 for Manjakiri and Waengnoi. Figure 6.3 shows the technical efficiency ratios compared with the visits per FTE ratios for all hospitals. However, the Pearson correlation coefficient of 0.687 ($p < 0.05$) suggests that the visits per FTE and TE score appear to be linked, although Phon, Sichompoo and Nampong showed some variation from that expected.

Finally for outpatient ANC, in South Africa the TE score is 1.0 for all health centres except U21 clinic, where it is 0.78 and where the visits per FTE are the lowest (see Appendix 7 Figure 7.2).



For the DEA in inpatient wards in Thailand, two models were run using inpatient days (IPD) and inpatient admissions (IPA) as the output measures. The results are presented in Appendix 7 Figure 7.3 show TE scores vary between 0.6 in Kranuan and 1.0 in four hospitals. The Pearson correlation coefficients of 0.358 and 0.347 for IPD and IPA respectively suggest that there is not a strong positive correlation between visits per FTE and both TE scores. One result that cannot be explained at this stage is that Khaosankuang is the least productive hospital in terms of visits per FTE, but attains a TE score of 1.0. Examining the data shows that the number of IPD per month is very low (522), but with a relatively large number of staff (522).

The DEA results discussed above are all under the assumption of variable returns to scale, which is justified on the premise that the marginal cost is less than average cost in all hospitals⁵⁴. The data were also tested under the alternative assumption of constant returns to scale. This had a surprisingly large effect on the TE score, reducing it by several tenths for some hospitals, but only with a marginal effect on others. The larger effects appeared to be on hospitals with lower throughput. Appendix 7 Table 7.1 shows all the DEA data from this chapter. A weakness of the DEA performed in this chapter is that only two inputs were included (staff numbers and building space), thus not covering the range of resources used in providing care. However, constraints on quantifying other

⁵⁴ This is the definition of variable returns to scale in IDEAS, the DEA software.

inputs in manageable and representative resource use indices prevented other inputs from being included.

6.2.2 Equipment

A first and general comment on the size and contents of these lists is that in all countries the lists are extensive, and some very expensive items appear on the lists which would not usually be found in typical health facilities in low income countries. In the policlinics in Cuba, for example, autoclaves worth over US\$2,000 were in common use, as well as expensive microscopes, centrifuges, air conditioning systems and refridgerators. Computers were also in commonly available, although not all records were entered on computer as they were not available in all departments. Also, cars have been purchased in a few policlinics. America Arias hospital was also well stocked with equipment, including ultrasound (US\$37,000), neonatal incubators (US\$7,000) and ventilator (US\$9,000), as well as a special analysis machine in the laboratory (US\$72,000) and computers. Therefore, the support departments (laboratories and sterilisation departments) in Cuba are well equipped to perform their tasks.

While for these reasons the equipment appears adequate for high quality health care, there were also some differences between policlinics in terms of the length of list of items worth over US\$200, with noticeably shorter lists in family doctor clinics in Manduley, Vantroi and Zulueta policlinics. Also, there were few items of equipment worth over US\$200 in the family doctor clinics. Most of these had a multipurpose table and special lamp (in the clinic) and a refridgerator and television (in the doctor's house), although some family doctor clinics had no or few valuable items (Galvan, Guiteras, Manduley). Some family doctors also had an autoclave, gynaecological bed and expensive electronic scales⁵⁵. Finally, an important point to note in terms of future investment requirements in the health sector is that it is also noticeable that all these equipment are many years old (10-30 years old), suggesting that the 'special economic situation' in Cuba is having its' effect in the health sector.

In Thailand, in general there was more and newer equipment in the district hospitals than the policlinics. The economic boom in Thailand in the early-mid 1990s meant that a huge investment programme was initiated in the health sector, giving district hospitals

the means to purchase many types of equipment. The most expensive equipment were hospital cars and ambulances worth over US\$20,000, followed by X-ray, ultrasound and dentistry equipment (US\$10-20,000) and laboratory or laundry equipment (US\$5-10,000). Many of these were imported from Japan, China, Germany, and the USA. Expensive surgical beds and lamps, laboratory equipment, refrigerators and televisions were also commonplace. However, in making comparisons, note that the polyclinics in Cuba did not provide inpatient care but did provide specialist care, whereas the district hospitals in Thailand provided inpatient and outpatient non-specialist care.

In South Africa, the health centres had minimal equipment worth over US\$200. Items recorded in all clinics were fridges, filing cabinets, delivery beds, and weighing scales. Some clinics had sterilising equipment and suction machines. A widely quoted reason for the low resourcing was that thefts occur with regularity from clinics, despite the presence of security guards 24 hours a day. However, the lack of equipment compared to Thailand and Cuba does not necessarily mean that nurses could not perform their functions properly. First, they received additional resource support from the hospital (such as laboratory tests and ambulances), and second the resources were more or less comparable to the family doctor clinics in Cuba which also have minimum equipment. Prince Mshiyeni hospital, on the other hand, was very well equipped with the items necessary for a secondary level general hospital. The most expensive equipment were neonatal incubators (US\$26-28,000) of which nine were found, and laboratory equipment (US\$25,000) of which five items were found. In addition to these, the neonatal room and laboratory had several other items in the top cost end of the equipment list. In the obstetric operating theatre there was a ventilator (US\$18,000), anaesthesia machine (US\$12,000) and defibrillator (US\$8,000). Also, in the labour room there were special items such as an 'Ivacs' (US\$9,000) and an ECG machine (US\$6,000).

In conclusion, both lower level (primary) and secondary level health facilities in study countries were well equipped to provide quality health care. However, some disparity was observed between some health facilities in Cuba and Thailand, but this was sometimes due to the health facility size, or special functions performed (for example,

⁵⁵ This is one of the problems of only sampling 4 family doctor clinics, as they may not be representative.

more emergency room or surgical patients). Due to the relative economic prosperity of Thailand and South Africa, there is more importation of high quality equipment from Europe, Japan and USA, rather than choosing cheaper domestically produced options. For Cuba, importing many items is the only option as many items are not domestically produced, but the country faces very high prices due to the restrictions on suppliers imposed by the US trade embargo⁵⁶.

6.2.3 Drugs

From the surveys of antenatal cards in Cuba and Thailand, exact drug use of a sample of women was recorded⁵⁷. Data from these two samples and other studies are discussed briefly. Table 6.5 below shows the number of prescriptions given to the sample of women in Cuba. The total prescriptions (shown in the end column) vary significantly by polyclinic, with between 4 (13 de Marzo) and 34 (Manduley) prescriptions given to the sample (all samples are between 14-16 women, except Escalona where it was 10). The total drug prescriptions in the intervention arm (102) exceeded those in the control arm (61) in the sample.

While drugs like diazepam and metronidazol were prescribed by providers in all polyclinics in Cuba, there was particular variability in the prescribing patterns of other drugs, such as clotrimazol, fumerato ferroso, vitamins, and the 'others' category. It was unknown whether doctors did not prescribe these drugs because the women had no need, or because they were not available in the pharmacies. Inconsistent recording may also have been responsible for some of the variations, such as whether or not vitamins were recorded. Also, a large component of 'drug' use is routinely provided drugs, such as 'prenatales', which contains multi-vitamins and iron folate, as well as the routine tetanus toxoid given to all women as needed. Therefore, the drugs listed in Table 7.5 only contribute a small proportion of total drug cost.

⁵⁶ The USA would be the cheapest source of import for many medical goods, but Cuba has to buy from more expensive suppliers due to the USA trade embargo.

⁵⁷ 'Scaling up' these data to the rest of the trial population was thought to give better estimates of drug cost than other methods identified.

Table 6.5: Prescriptions given to sample of pregnant women in Cuba, by policlinic.

Policlinic	Sample size	Diaz	Fum	Clot	Met	Ben	Sulf	Folic	Inf	Vit	Other	Total drugs
<i>Intervention</i>												
13 de Marzo	15	2	0	1	1	0	0	0	0	0	0	4
Albarran	16	1	0	4	3	1	1	0	0	0	3	13
Galvan	14	2	0	3	4	0	1	0	0	0	0	10
Manduley	15	6	0	9	4	0	1	1	0	6	7	34
Romay	14	2	0	9	4	4	5	0	1	0	5	30
Zuluetta	15	0	1	9	1	0	0	0	0	0	0	11
<i>Control</i>												
Abaili	15	4	0	1	4	0	1	0	1	0	0	11
Escalona	10	1	0	3	1	0	1	0	0	0	1	7
Guiteras	14	4	3	5	2	0	0	1	0	4	1	20
Reina	15	2	2	0	5	0	1	2	0	0	0	12
Tamayo	15	1	0	2	1	0	0	0	0	1	0	5
Vantroi	15	2	1	0	1	0	2	0	0	0	0	6
ALL	183	27	7	46	31	5	13	4	2	11	17	163

DRUG KEY and USES: Diaz – diazepam (hypertension); Fum – fumarato ferroso (anemia), Clot – clotrimazol (trichomoniasis); Met – metronidazol (vaginal parasites); Ben – penicillin benzatinica (infection); Sulf – sulfaprim (urinary sepsis) and sulfamida (vaginal parasites); Inf – inferon (anemia); Vit – vitamins (C, B12, B6); Other – duragina (analgesic), tiroide (hypothyroidism), indometacina (anti-inflammatory), nistatina (manilia), fenoterol (abortion threat), gravinol (anti-hystemine).

The use of prescriptions was also variable between hospitals in Thailand, although consistently lower rates per woman were observed compared to Cuba. Obumin, 'nataval' (vitamins and folic acid), and ferrous sulphate were provided to all women, although in differing quantities. For many hospitals, no additional prescriptions were given to the sample women. For others, a few drugs were given such as amoxytocin, ammunilk (an anti-acid), methergin (prevent and treat postpartum hemorrhage), bricanyl (treat pre-term labour), and others. The hospital with the most prescriptions were Nampong and Nongsonghong (4 prescriptions) and Kranuan (5 prescriptions).

In South Africa the method of recording drug use of a sample of 15 women per clinic was not used, and instead monthly quantities of drugs typically given to pregnant women were recorded. Two categories were distinguished: those drugs provided to pregnant women by the health care providers such as ferrous sulphate and paracetamol, and those drugs that pregnant women picked up from the pharmacy such as penicillin, methyldipa, and stronger painkillers such as ibuprofen. Comparison of the quantity of drugs used every month with the numbers of pregnant women suggests quite an intensive use of prescribed drugs.

6.2.4 Materials

Typical medical supplies recorded in all countries included gauze, bandage, alcohol for medical use, detergent, thermometers, distilled water, soap, peroxide. Materials also included those for general use (such as cleaning materials and floor polish) and those for use in the laboratory. In Cuba, the laboratory was consistently the most intensive user of materials in all polyclinics. However, in some polyclinics it was evident that some basic materials such as soap and detergent were often not supplied for family doctors. In South Africa, all the essential materials were supplied on a monthly basis, and no serious shortages were noted. A large proportion of materials in Prince Mshiyeni hospital were consumed by the laboratory, delivery room, nursery and obstetric operating theatre, with the inpatient wards and outpatient clinics using significantly less materials (non-maternity health care departments were not included in the study).

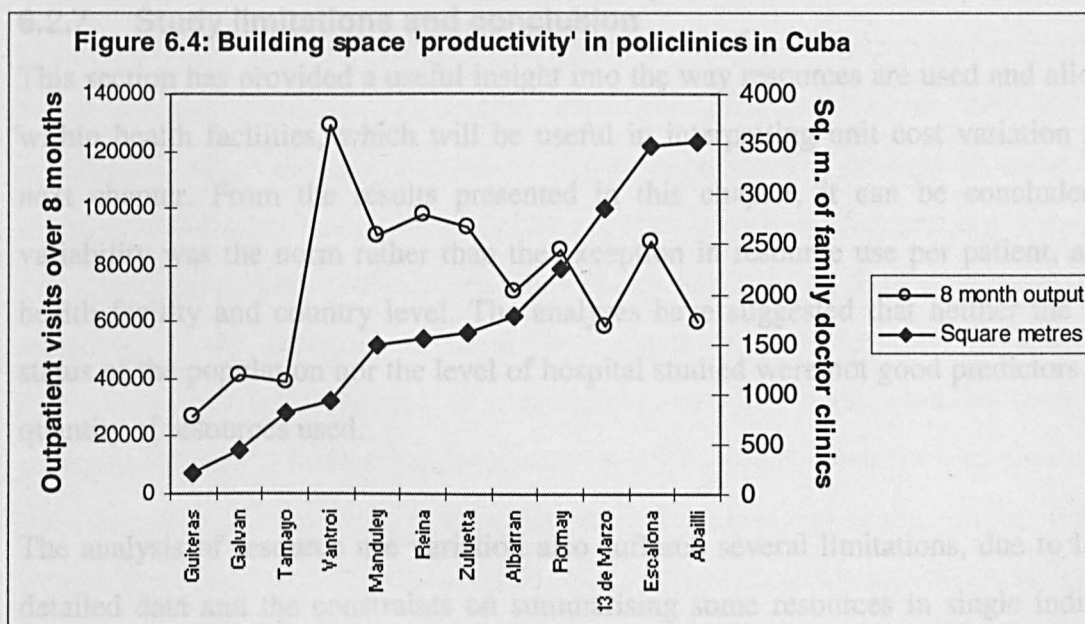
In Thailand also, the outpatient clinics and inpatient wards consumed a relatively small share of materials compared to the laboratory, emergency room, operating theatre (general) and dentistry. Disinfectant and cleaning materials were by far the most costly item regularly supplied to all the departments. In neither Cuba nor Thailand did it appear that material quantities delivered differed systematically between trial arms.

6.2.5 Utilities

The representation and comparison of 'utilities' in physical quantities is the most difficult of all the resources, but is broadly similar across all countries in that adequate utilities were available to run a minimum quality health service. For example, electricity use is difficult to discern at the department or clinic level, and particularly at the individual patient level. The use of some utilities appeared to be fairly uniform within the health facilities, such as water and electricity, although some departments such as laboratory made heavier use of these as suggested by the numbers of taps and electrical machinery. Gas tended to be used more by the kitchen and laboratory, and was often supplied by canisters rather than on mains. External telephone lines tended to be used more by administration departments. Internal telephone lines were not counted, as they were costless to use once installed. While data were available on approximate use by the cost centres for all the utilities, it was not thought to be a fruitful use of time to analyse these data before they were converted to costs (see Chapter 8 for unit costs).

6.2.6 Buildings

Details of buildings were collected, with details of room numbers and size within each department grouping, and the proportion of the total health facility. In Cuba, polyclinic buildings were surprisingly uniform in size, with most around 600-800 m² (average 693 m²). Albarran is the smallest (398 m²) and Guiteras the largest (1334 m²). However, the size of polyclinic did not necessarily correspond to output (outpatient visits). The variable more closely related to output was the total size of family doctor clinics, most of which are located outside the polyclinic building. Figure 6.4 shows the relationship between floor space in the family doctor clinics and output. The Pearson correlation coefficient of 0.225 suggests that building space is not an important determinant of monthly output, and this is confirmed by visual inspection. For example, Vantroi has a very high output for its' small size. Also, Guiteras has by far the lowest space in its' family doctor clinics, because most of them (11 out of 15) are located inside the polyclinic building, and these rooms are very small, giving Guiteras a space productivity ratio almost as high as Vantroi.



In Thailand, there is a significant variation in visits per square metre between hospitals, and again, there is limited association between building space and monthly output. For example, Banphai, Khaosankuang, Puieng and Nongrua all have significantly more building space than the other hospitals, but do not necessarily produce more output.

The results of this section help explain the technical efficiency scores, as building space is the second input to the DEA reported earlier. Using the data presented, it is possible to conclude that part of the reason that Khaosankuang and Nongrua had low technical efficiency scores was that they had low staff and building productivity. Judging by visits per FTE alone, Banphai should have a TE score close to 1.0, but it also has very low visits per square metre, thus explaining why the TE score is 0.8 instead.

Finally, for inpatient care the number of days per square metre per month was similar between country, with most wards falling in the range 1.5-2.5 days per square metre per month. As with the measure 'visits per FTE' the high risk wards are expected to have lower rates of days per square metre, which was true in Cuba. However the high risk wards in South Africa (both pre- and postpartum) had higher output rates than the low risk wards, and this was not due to higher occupancy. Hospitals in Thailand showed the greatest variability, varying from 0.72 to 4.28 days per square metre, with an average of 1.76 for all hospitals.

6.2.7 Study limitations and conclusion

This section has provided a useful insight into the way resources are used and allocated within health facilities, which will be useful in interpreting unit cost variation in the next chapter. From the results presented in this chapter, it can be concluded that variability was the norm rather than the exception in resource use per patient, at both health facility and country level. The analyses have suggested that neither the health status of the population nor the level of hospital studied were not good predictors of the quantity of resources used.

The analysis of resource use variation also suffered several limitations, due to lack of detailed data and the constraints on summarising some resources in single indices. It was found that staff were the most amenable to conduct data analyses, although it too had limitations. For example, the analysis of average staffing levels did not take into account difficulties in staff recruitment, day-to-day reallocations of staff between departments, and the fact that staff numbers in support departments were not included in the ratios (thus suggesting that a potential further source of variability was missed).

A weakness of the DEA approach in calculating a technical efficiency score was that only two inputs (staff numbers and building space) were used. This reflects more the difficulties of appropriate quantification of inputs than underlying problems with the DEA method itself. Other resources could have been included, such as numbers of drug prescriptions, but this would not have allowed for differences in case-mix between health facility. Therefore, technical efficiency scores should be interpreted with the fact in mind that only two resource ingredients were included.

In addition, there may be case-mix, quality or and demand uncertainty differences not analysed that may explain differences observed in resource use. Other functional duties of staff may not be captured by the output measures used. Differences in the daily activities of staff causing different ratios should be taken into account in interpreting the data, such as the fact that family doctors in Cuba spend half the day 'in the field' where they see less patients per hour than in the clinic.

Comparisons of resource use are also hampered by cross-country differences in resource type, such as the age, specifications and quality of equipment or training levels of staff. Also, the availability of equipment does not necessarily mean they are used productively. For example, computers may be used more effectively in some health facilities than others, due to the availability of staff trained in programming or computer use. The cross-country comparisons also need also to be interpreted with the economic situations of the countries in mind. In Cuba recently, both recurrent and capital expenditure has been reduced to a minimum, with focus on essential drugs (thus pregnant women in Cuba are quite looked after with respect to drugs). In Thailand, on the other hand, there were large expenditures on buildings and equipment recently, with imported products rapidly increasing. In South Africa, a country relatively rich in terms of health sector spending per capita, equipment was minimal in the health centres due to the security situation, and also because they are supported by the secondary hospital.

7 CAUSES OF VARIATION IN UNIT COST

The aims of this chapter are to identify and analyse variations in unit costs of selected health services. Unit cost differences are examined using a series of cost analysis tools described in the methods chapter, and implications of the results for the generalisability of costs are drawn. In the first section, unit cost variation is analysed within country, both between trial arm and between individual health facilities or wards. In the second section, unit cost variation is analysed between countries, and ranges on average costs are calculated using sensitivity analysis to reflect greater uncertainty in cross-country comparisons of unit cost. Each section begins by identifying whether unit cost variations are statistically and economically significant. In particular, those factors influencing unit cost are compared between the high and low cost providers, to see whether unit cost differences identified can be explained. While the focus of the analysis is on average costs, conclusions are also made about variability in marginal costs.

7.1 Unit cost variations within countries

7.1.1 Outpatient care

7.1.1.1 Size of differences

Table 7.1 below shows that the pooled average cost per outpatient antenatal care visit in Cuba⁵⁸ of US\$12.18 in the intervention policlinics (95% confidence interval US\$9.05-15.31) was almost identical to the control policlinics of US\$12.12 (US\$8.99-15.60). The marginal cost, however, was US\$1.14 more in the intervention arm policlinics. Although this difference was not statistically different, the 95% confidence interval on the difference was close to zero (-US\$2.5 to US\$0.20, $p=-0.027$). The economic difference was 9.4% of the average cost of an antenatal visit. Therefore, there is no definitive proof that the new antenatal care programme alters unit costs of outpatient care, nor is the difference observed economically significant⁵⁹.

⁵⁸ The nominal exchange rate was US\$1=1 Peso on 8 January 1998.

⁵⁹ While there was an observed reduction in outpatient visits made by pregnant women to intervention policlinics, this reduction did not affect average costs because the overall reduction in outpatient visits was marginal compared to the total throughput of outpatients in policlinics.

While there was no observed change in average cost between trial arms, variation between individual policlinics was considerable. Appendix 9 Table 9.1 and Appendix 9 Figure 9.1 show that average cost in policlinics varies between US\$8.28 and US\$18.36, with many statistically significant differences arising⁶⁰. The average cost per outpatient antenatal visit was the lowest in America Arias hospital at US\$3.22 (95% CI US\$2.82-3.62). The coefficient of variation (standard deviation ÷ mean) ranged from 0.06 (Escalona) to 0.28 (Guiteras) in policlinics, thus suggesting greater inter-month variability in average costs in some policlinics⁶¹.

Table 7.1: Average and marginal costs per ANC visit in Cuba and Thailand.

Country and trial arm	Average cost per visit (US\$)				Marginal cost per visit (US\$)	
	Lower	Mean	Upper	COV	Mean	% AC
Cuba						
Intervention group	9.05	12.18	15.31	0.27	4.72	0.39
Control group	8.64	12.12	15.60	0.30	3.58	0.31
<i>Difference (95% CI)</i>	-4.48	0.06	4.36	<i>P=0.73</i>	1.14 (-2.5-0.2)	<i>P=0.027</i>
Thailand						
Intervention group	5.73	6.56	7.39	0.23	1.45	0.22
Control group	4.92	5.83	6.73	0.28	1.47	0.24
<i>Difference (95% CI)</i>	-2.74	0.73	1.28	<i>P=0.673</i>	0.02 (-1.05-1.07)	<i>P=0.746</i>

In Thailand⁶², the pooled average cost per visit in the intervention hospitals of US\$6.56 (US\$5.73-7.39) is greater than in the control hospitals of US\$5.83 (US\$4.92-6.73), but this difference of US\$0.73 is not statistically significant ($p=0.673$). This extra cost amounts to 12.5% the average cost of an antenatal visit. However, there is no difference in marginal cost. Therefore, there is no definitive proof that the new antenatal care programme altered unit costs of outpatient care in Thailand, nor is the difference observed economically significant.

Appendix 9 Table 9.1 and Appendix 9 Figure 9.2 show that average cost also varies significantly between individual district hospitals in Thailand, from US\$3.62 to US\$9.13 per visit. The coefficient of variation ranges between 0.08 (Banphai and

⁶⁰ As discussed in Chapter 5, the confidence intervals for individual health facilities were based on variability between unit costs for months over the sample time period; however, it is recognised that this did not necessarily capture the actual variability in unit costs, as unit costs also vary at the patient level. However, the confidence intervals from month-to-month variability may have been greater than confidence intervals from patient-to-patient variability. This was because the most important resource varying between patients was drug cost, which is a much lower cost contributor than staff cost. Therefore, findings of significant difference between unit costs using these data are interpreted with this in mind.

⁶¹ Month-to-month variability in unit costs was tested for serial correlation in all countries, but none was found.

⁶² The nominal exchange rate was US\$1=52.3 Baht on 8 January 1998.

Nongrua) and 0.26 (Nampong). The average cost of an antenatal visit is lower in both referral hospitals, with an average cost per visit of US\$2.75 in Khon Kaen hospital and US\$2.10 in Sririgarind hospital⁶³. Appendix 9 Table 9.1 and Appendix 9 Figure 9.3 also shows average and marginal costs per antenatal visit in clinics and Prince Mshiyeni hospital in South Africa⁶⁴. Average costs vary from US\$6.37 in L clinic to US\$8.63 in Q clinic, and to US\$9.05 in the hospital (all differences are statistically non-significant). Marginal costs in the clinics vary between US\$0.36 and US\$0.56 (average US\$0.42), and is US\$0.95 in Prince Mshiyeni hospital.

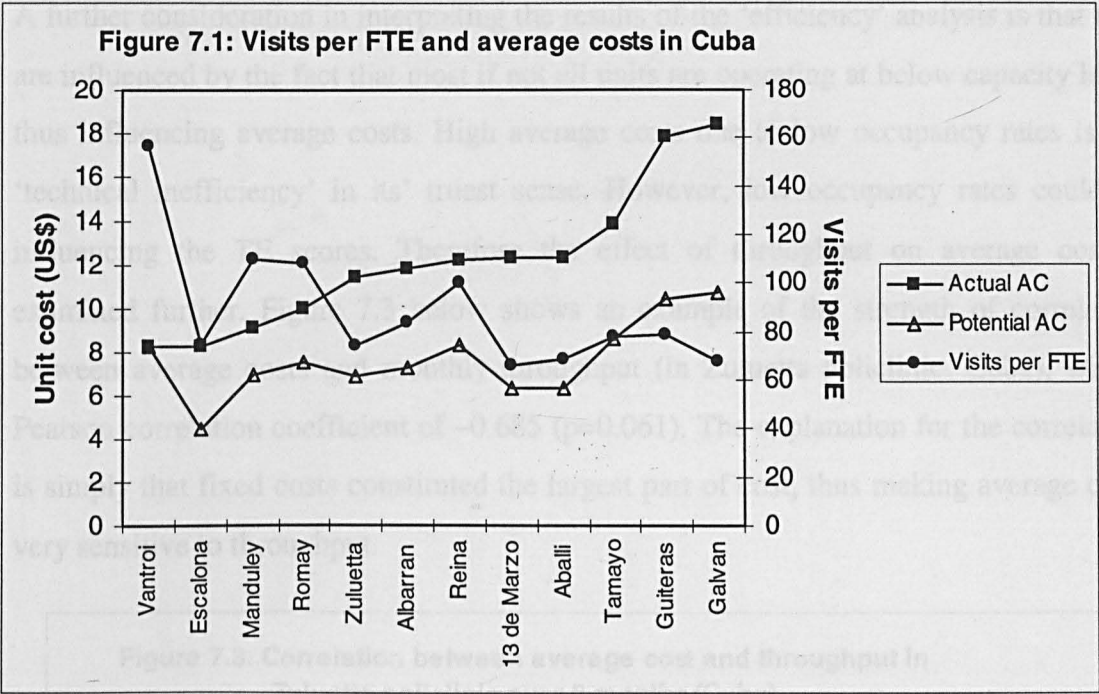
7.1.1.2 Causes of ANC outpatient unit cost variation in Cuba

In the following analysis, the specific aims are to explain why average costs are lower in Manduley, Escalona and Vantroi policlinics, and why average costs are higher in Galvan and Guiteras. In terms of efficiency measured by visits per FTE, Figure 7.1 below shows a clear, though not perfect, negative correlation between unit costs and visits per FTE. The Pearson correlation coefficient of -0.554 confirms that correlation may exist, but it is not significant ($p > 0.05$). The number of visits per FTE ranged from 66 to 157 per month (average 89) in the policlinics, and to 284 in America Arias hospital. In most cases a high average cost is associated with low visits per FTE, and vice-versa. However, Escalona has low staff productivity, thus suggesting other causes for its' low average cost. Other policlinics appearing not to have the expected negative correlation between visits per FTE and average cost are Zulueta, 13 de Marzo, and Abailli policlinics.

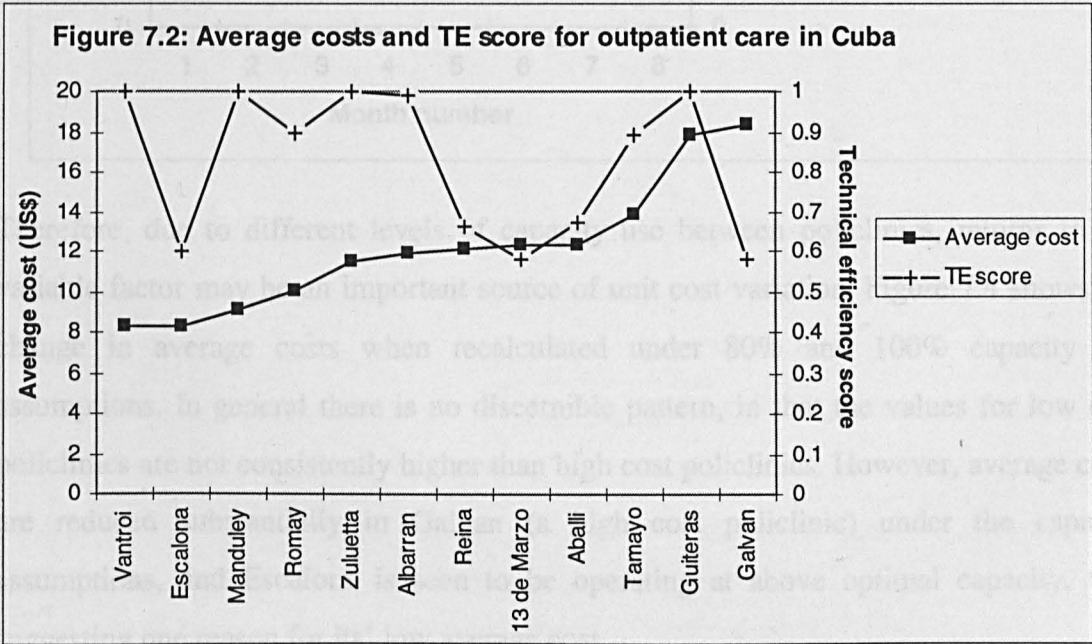
Figure 7.1 also shows average costs recalculated (termed 'potential AC') with the visits per FTE of the most efficient policlinic (Vantroi), to see whether average costs converge. Although some convergence is noticeable (particularly in the higher cost policlinics), divergence is also observed, especially for Escalona. An encouraging result for explaining cost variation is that average costs in Galvan and Guiteras are reduced by around US\$7, taking them closer in terms of average cost to other policlinics.

⁶³ However, these data were gathered from other studies, and therefore some of the difference may be caused by differences in costing methods. Also, as the study in Sririgarind hospital was done in 1989, the inflation adjustment factor (of 6% per year) may underestimate the true hospital cost inflation over that period.

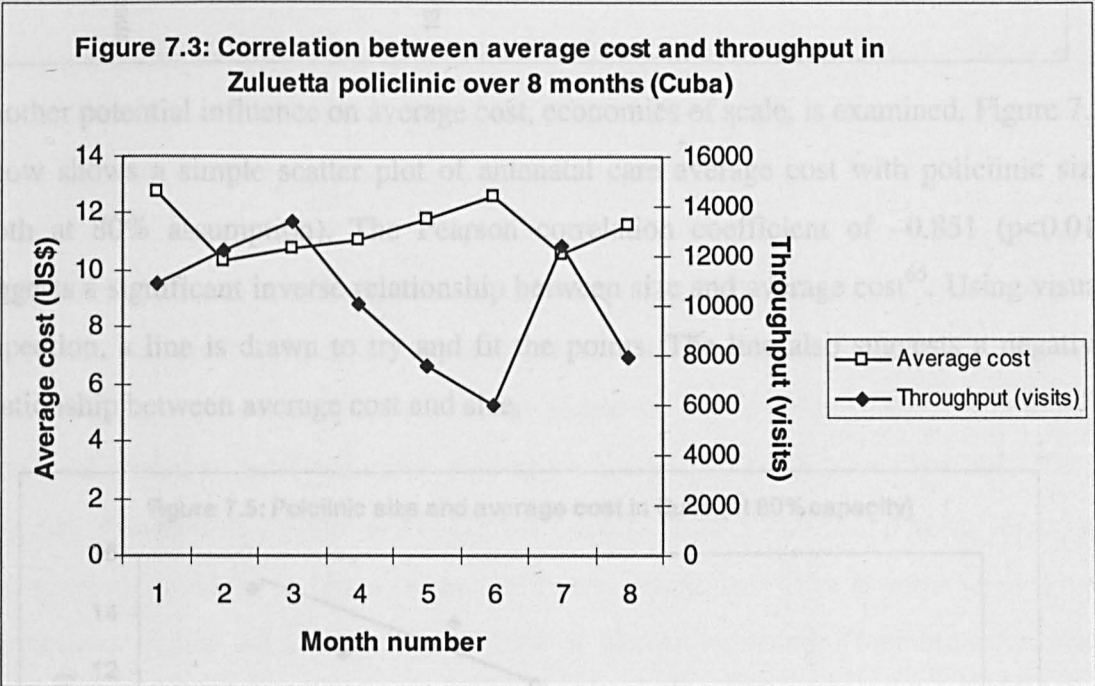
⁶⁴ The nominal exchange rate was US\$1=4.93 Rand on 8 January 1998.



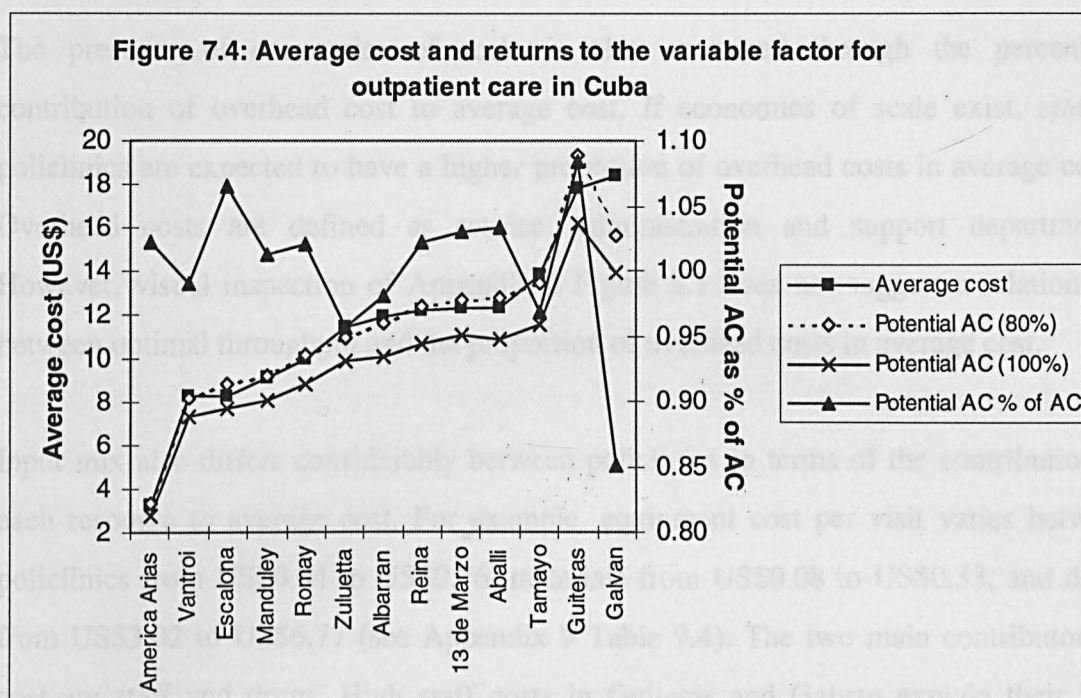
Policlinic efficiency is also measured using data envelopment analysis. Figure 7.2 shows that more of the policlinics in the lower end of average cost have higher TE scores; however, the inverse relationship suggested by the Pearson correlation coefficient of -0.169 does not suggest that a clear relationship existed. Notable exceptions are Guiteras and Tamayo which had a high average cost and high TE score, and Escalona which had a low average cost and a low efficiency score.



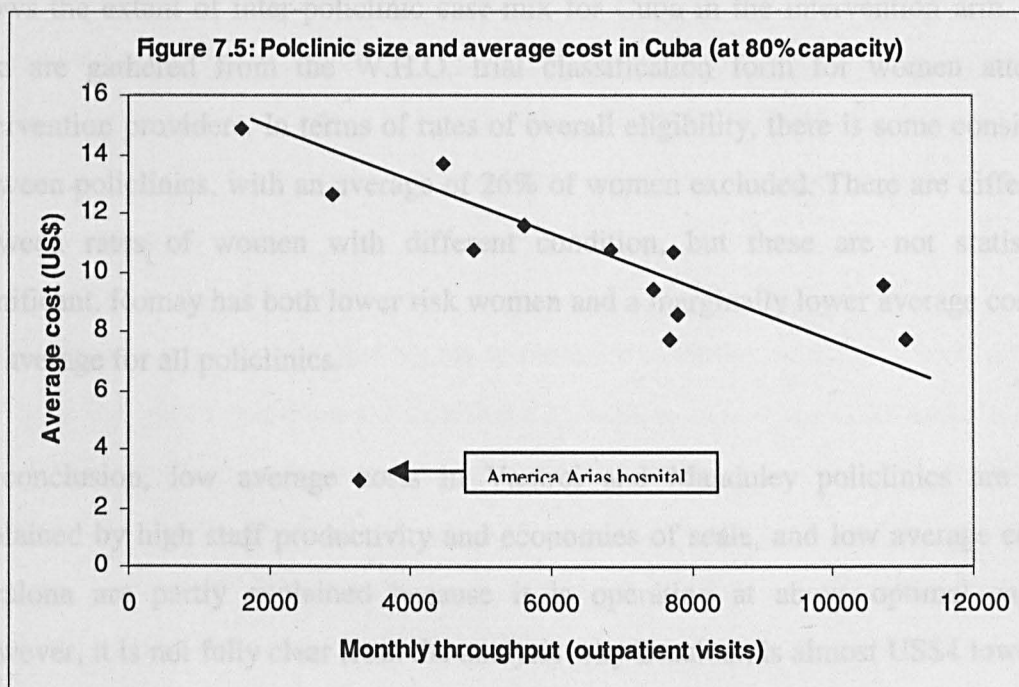
A further consideration in interpreting the results of the ‘efficiency’ analysis is that they are influenced by the fact that most if not all units are operating at below capacity level, thus influencing average costs. High average costs due to low occupancy rates is not ‘technical inefficiency’ in its’ truest sense. However, low occupancy rates could be influencing the TE scores. Therefore the effect of throughput on average cost is examined further. Figure 7.3 below shows an example of the strength of correlation between average costs and monthly throughput (in Zuluetta policlinic, Cuba), with a Pearson correlation coefficient of -0.685 ($p=0.061$). The explanation for the correlation is simply that fixed costs constituted the largest part of cost, thus making average costs very sensitive to throughput.



Therefore, due to different levels of capacity use between policlinics, returns to the variable factor may be an important source of unit cost variation. Figure 7.4 shows the change in average costs when recalculated under 80% and 100% capacity use assumptions. In general there is no discernible pattern, in that the values for low cost policlinics are not consistently higher than high cost policlinics. However, average costs are reduced substantially in Galvan (a high cost policlinic) under the capacity assumptions, and Escalona is seen to be operating at above optimal capacity, thus suggesting one reason for its’ low average cost.



Another potential influence on average cost, economies of scale, is examined. Figure 7.5 below shows a simple scatter plot of antenatal care average cost with polyclinic size (both at 80% assumption). The Pearson correlation coefficient of -0.851 ($p < 0.01$) suggests a significant inverse relationship between size and average cost⁶⁵. Using visual inspection, a line is drawn to try and fit the points. The line also suggests a negative relationship between average cost and size.



⁶⁵ The outlier, America Arias hospital, is excluded from this calculation.

The presence of economies of scale is also examined through the percentage contribution of overhead cost to average cost. If economies of scale exist, smaller polyclinics are expected to have a higher proportion of overhead costs in average costs. Overhead costs are defined as service, administration and support departments. However, visual inspection of Appendix 8 Figure 8.1 does not suggest a relationship between optimal throughput and the proportion of overhead costs in average cost.

Input mix also differs considerably between polyclinics in terms of the contribution of each resource to average cost. For example, equipment cost per visit varies between polyclinics from US\$0.04 to US\$0.26, materials from US\$0.08 to US\$0.33, and drugs from US\$3.02 to US\$6.77 (see Appendix 9 Table 9.4). The two main contributors to cost are staff and drugs. High staff costs in Guiteras and Galvan explain their high average costs; low staff costs in Vantroi and Escalona explain their low average cost; high drug costs also explain the high average cost in Guiteras.

The impact of case-mix on health service use was examined in detail in the last chapter. In this section, the impact of case-mix on average costs is examined briefly, although the conclusions that can be drawn from these data are limited. Appendix 10 Table 10.1 shows the extent of inter-polyclinic case-mix for Cuba in the intervention arm. These data are gathered from the W.H.O. trial classification form for women attending intervention providers. In terms of rates of overall eligibility, there is some consistency between polyclinics, with an average of 26% of women excluded. There are differences between rates of women with different condition, but these are not statistically significant. Romay has both lower risk women and a marginally lower average cost than the average for all polyclinics.

In conclusion, low average costs in Vantroi and Manduley polyclinics are partly explained by high staff productivity and economies of scale, and low average costs in Escalona are partly explained because it is operating at above optimal capacity. However, it is not fully clear from the analysis why Escalona is almost US\$4 lower cost than the average cost for all polyclinics. High average costs in both Galvan and Guiteras are explained by low staff productivity, and also due to small overall polyclinic size. However, Guiteras is also operating at above optimal capacity.

7.1.1.3 Causes of outpatient ANC unit cost variation in Thailand

In this analysis, the specific aim is to explain why average costs are very low in Nongsonghong, and low in Puvieng, Nongrua and Sichompoo, and why average costs are high in Khaosankuang and Kranuan (Appendix 9 Table 9.1 and Appendix 9 Figure 9.1). In terms of efficiency measured by visits per FTE, Appendix 8 Figure 8.2 shows the inverse relationship between visits per FTE and unit costs does exist in Thailand, which according to the Pearson correlation coefficient of -0.568 is close to statistical significant at the 5% level ($p=0.054$). Visits per FTE in the health promotion units of district hospitals vary from 34.3 (Khaosankuang) to 151.0⁶⁶ (Nongsonghong), with an average of 97. The relationship therefore suggests that the low average cost in Nongsonghong is partly due to very high visits per FTE, whereas the high cost in Khaosankuang is partly due to low visits per FTE. However, the low visits per FTE observed in Sichompoo and Nampong do not predict high average costs. Also, average costs in Kranuan are high, despite a medium level of visits per FTE. Further evidence that differences in visits per FTE cause average cost variations is shown by the fact that the average cost line converges when recalculated using the visits per FTE of the most 'productive' hospital (Nongsonghong).

Using the technical efficiency score, Appendix 8 Figure 8.3 shows that there is no clear inverse relationship apparent with average cost. For example, Nongsonghong and Puvieng have generally low TE scores, while Kranuan and Khaosankuang have TE scores of 1.0. For the hospitals with medium average cost, there is little consistency apparent in the TE score.

Differences in capacity use also appear to have little bearing on average cost. Appendix 8 Figure 8.4 shows that there are significant reductions in average costs under both 80% and 100% capacity use assumptions. However, under these assumptions, average costs between the district hospitals do not converge. For example, hospitals with medium average costs have the biggest cost reductions under capacity use assumptions (Sichompoo and Waengnoi).

⁶⁶ Note that Sichompoo, Waengnoi and Nongsonghong operated the ANC clinic for one day a week, instead of two like the other hospitals.

Economies of scale do not appear to be present to the same degree as in Cuba, although two interpretations are possible from the data, a horizontal line (constant returns to scale) and a downward sloping line (see Appendix 8 Table 8.5). However, a high degree of variability prevents a strong conclusion concerning the existence of economies of scale. The Pearson correlation coefficient of -0.251 confirms that it is unlikely economies of scale existed in Thailand.

A similar examination of case-mix, as measured by trial eligibility in the intervention arm, is conducted for Thailand (Appendix 10 Table 10.2). The data show that women in Chumpae (9% ineligible), KSK (7%) and Waeng Noi (7%) are relatively more healthy (compared to an average of 11% of women excluded from the new package). However, these hospitals are middle or high average cost hospitals. In none of the cases are hospitals with lower rates of risk status also lower average cost hospitals. An alternative measure of case-mix, women's health outcomes, show significant variability between hospitals, such as for STD treatment rates, UTI, HDP, and bleeding, but there is no or limited correlation with average costs recorded.

In conclusion, hospitals in Thailand with high or low average costs cannot be explained in terms of the available indicators as well as in Cuba. Actual versus predicted average cost in Puveng, Kranuan and Sichompoo have the greatest divergence. For example, Kranuan is not predicted to have a high average cost (except for high materials cost). Also, many hospitals with low or medium average costs are predicted to have high average costs, such as Puveng and Sichompoo. However, some hospitals are more in line with expectations. For example, Khaosangkuang is correctly predicted to have higher average costs, due to the very low visits per FTE. Also, Manjakiri and Phon are correctly predicted to be medium cost hospitals.

7.1.1.4 Causes of outpatient ANC unit cost variation in South Africa

Although there were no statistically significant differences in average cost between clinics or the hospital in South Africa, it is worth examining the same indicators as above, in order to see whether average costs are at expected levels. Appendix 8 Figure 6 shows that visits per FTE are lower in the clinics with higher average costs, but there was limited convergence in average costs when calculated using the visits per FTE of H

clinic. Note, however, that H clinic with the highest visits per FTE did not have the lowest average cost in the sample.

The TE score shows three clinics to have a score of 1.0. U21 achieves roughly 80% the efficiency as the other clinics, and Q clinic 86%. These results are consistent with expectations, that the higher cost clinics are not as efficient as lower cost clinics. The effect of capacity use assumptions on average cost, except for Q clinic, are inconsistent with expectations. Appendix 8 Figure 8.7 shows that the lower cost clinics have lower capacity use than the others (not as expected), while Q clinic has the greatest reduction in average cost under the capacity use assumptions (as expected). Therefore, except for Q clinic, there is no convergence in AC under alternative assumptions.

Economies of scale are not evaluated for South Africa, as no correlation could be examined with a sample size of only five clinics (four of them have a similar size). However, note that the largest clinic is not the cheapest, and the smallest clinic is not the most expensive, suggesting that economies of scale are unlikely to exist. Input mix, on the other hand, did not vary significantly between clinic, except drug cost is higher in H clinic, but not enough to impact the rankings of average cost between clinics. Case-mix is also not evaluated in the same way as the other countries, as the trial risk classification form was not applied to the sample of women in the outcome survey. Also, the data from the survey is not disaggregated by which clinic they attended. However, it can be said in general terms that the clinics are no different in that none have special functions for treating women at risk, and they serve the same populations.

In conclusion, although less cost analysis were used for South Africa compared to the other countries, some important cost determinants were identified, including staffing productivity and occupancy rates (see Appendix 10 Table 10.3 for comparisons).

7.1.2 Inpatient care

7.1.2.1 Size of variations

Table 7.2 shows average and marginal costs for inpatient care in all countries. The types of comparison made in this section are similar to those made in the last section, with more attention to the impact of variations in case-mix explaining unit cost differences. This is especially important when comparing low- and high-risk wards, or adult and

neonatal wards. In Cuba, average costs per inpatient day are higher in the high risk wards (wards AB and F) than the low risk wards ($p<0.05$). Also, the neonatal intensive care unit is by far the most expensive form of care. Cost per admission also varies between wards, and again the high risk wards are more costly per admission. However, ALOS in the low risk antenatal ward is over 3 days longer than the high risk antenatal ward, a surprising result given illness severity is supposed to be less there. Marginal cost as a proportion of average cost is stable across wards (20-27%).

In Thailand, the average cost per day in the control and intervention hospitals are similar, at US\$6.50 (95% confidence interval US\$5.74-7.26) and US\$6.62 (95% CI US\$5.30-7.94) respectively. Marginal cost per day is also similar, averaging 14-15% of average cost. Cost per admission is similar between trial arms, although the ALOS is on average longer in the control hospitals (not significant). Appendix 9 Table 9.2 shows that average costs for hospitals individually varied significantly, between US\$3.34 (95% CI US\$2.95-3.73) in Chumpae to US\$10.60 (95% CI US\$9.69-11.51) in Khaosangkuang ($p<0.05$).

Table 7.2: Average and marginal costs of inpatient care in study countries.

COUNTRY and TYPE of CARE	Average cost (US\$)				Marginal cost (US\$)		Cost per IPA (US\$)	
	Lower	Mean	Upper	COV	Mean	% AC	ALOS	Cost
CUBA								
ANC high risk (AB)	39.37	51.72	64.07	0.25	10.39	0.20	9.65	500
ANC low risk (E)	23.95	30.84	37.72	0.23	6.80	0.22	13.31	410
Post VD ward (C)	13.89	16.76	19.63	0.18	4.04	0.24	3.15	53
Post CS ward (F)	29.14	36.75	44.35	0.21	8.78	0.24	5.92	218
Neonatology	88.37	118.09	147.82	0.26	31.32	0.27	11.27	1331
THAILAND								
Intervention average	5.30	6.62	7.94	0.36	1.00	0.15	2.90	19
Control average	5.74	6.50	7.26	0.21	0.94	0.14	3.42	22
SOUTH AFRICA								
ANC high risk (ANW)	27.24	33.13	39.02	0.11	1.51	0.05	4.25	141
ANC low risk (E1)	29.34	30.56	31.78	0.03	1.26	0.04	3.04	93
Post VD ward (E2)	22.57	27.67	32.77	0.12	3.34	0.12	1.90	53
Post VD ward (E5)	27.30	32.34	37.37	0.10	2.18	0.07	6.19	200
Post CS ward (E3)	24.63	26.25	27.86	0.04	3.64	0.14	7.48	196
Post CS ward (E4)	21.84	26.21	30.58	0.10	2.24	0.09	1.88	49
Nursery	23.47	27.85	32.24	0.10	3.12	0.11	2.23	62

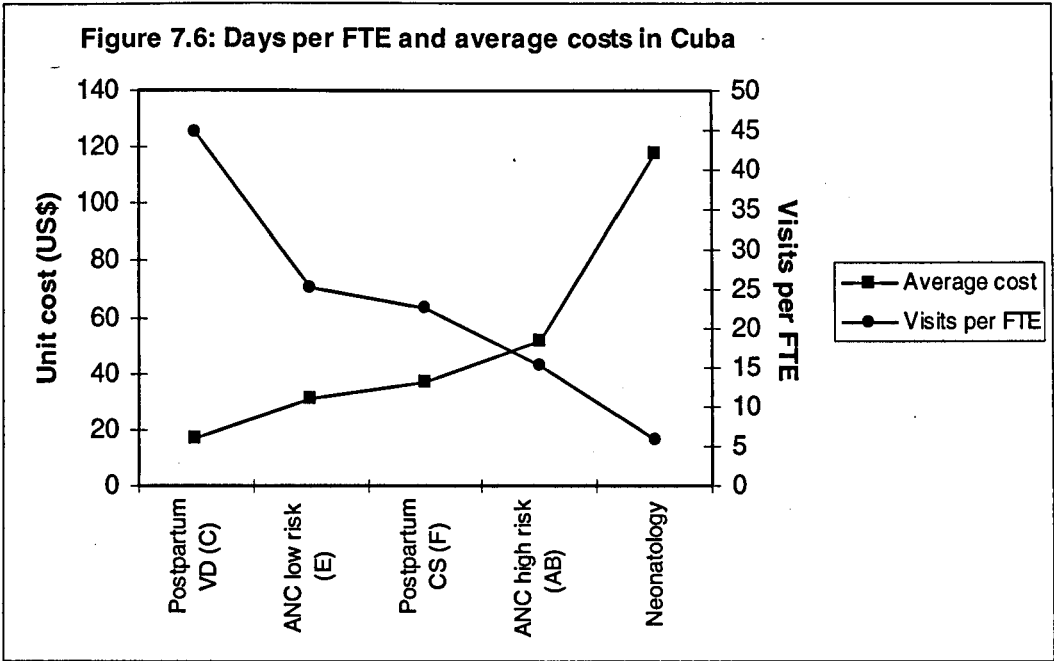
TABLE KEY: COV – coefficient of variation (standard deviation/mean); AC – average cost; IPA – inpatient admission; ALOS – average length of stay; VD – vaginal delivery; CS – caesarean section.

In South Africa, the average cost per inpatient day in Prince Mshiyeni hospital is cheaper for low risk antenatal care (US\$30.56) than high risk antenatal care (US\$33.13) ($p>0.05$). However, both post-CS wards are lower cost than post-VD wards (statistically

non-significant difference). Neonatal care has a similar cost per day (US\$27.85 per day) as adult inpatient care. Marginal costs vary between 4-14% of average cost between wards. The average cost per admission ranges between US\$49 and US\$200, although the large variation reflects more the fact that women are frequently transferred between wards than actual variation in cost per inpatient admission between wards.

7.1.2.2 Causes of inpatient care unit cost variation in Cuba

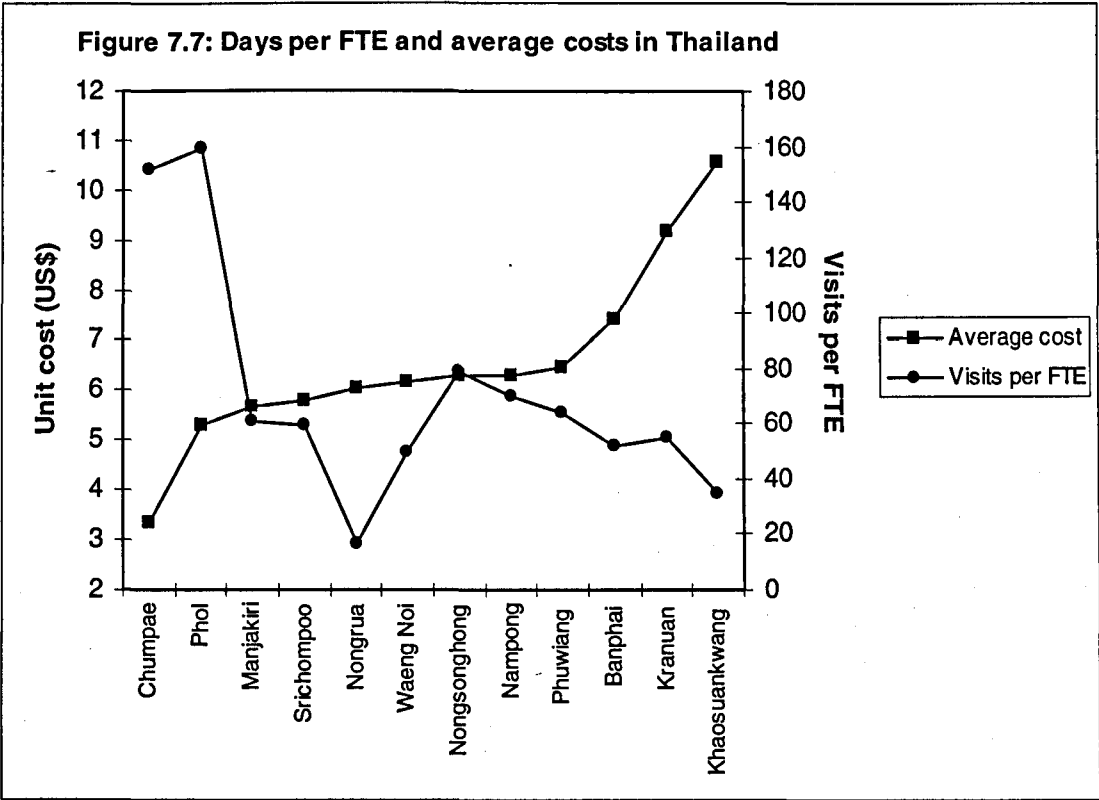
While case-mix differences no doubt explain a large part of variation between wards, the extent to which this affects efficiency measures is explored briefly. Figure 7.6 below shows a strong negative correlation between days per FTE and average cost for inpatient care.



Except for neonatal care in America Arias hospital, average occupancy levels are similar in all wards, and thus similar reductions are seen in average cost under 80% capacity assumption. The existence of spare capacity in the neonatal unit partly explains the higher unit costs there. Wards are similar in number of beds, and therefore economies of scale are unlikely to be responsible for average cost differences. Generic case-mix data are not available to examine the extent to which differences causes the variation in average cost between wards, although the high risk antenatal ward, post-CS ward and neonatal intensive care unit obviously have a heavier case-mix than the other wards.

7.1.2.3 Causes of inpatient care unit cost variation in Thailand

Causes of low average cost in Chumpae and Phon are sought, as well as causes of high average costs in Khaosangkuang, Kranuan and Banphai. Figure 7.7 below shows the relationship between days per FTE and average cost for inpatient care. The Pearson correlation coefficient of -0.603 ($p<0.05$) indicates a significant relationship. Using visual examination, it can be seen that the high cost hospitals have low days per FTE, while the low cost hospitals have the highest days per FTE, although several hospitals (Manjakiri, Si Chompoo, Nongrua and Waengnoi) are inconsistent.



Appendix 8 Figure 8.8 shows mixed evidence for the inverse relationship between the TE score and average costs. On the one hand, Chumpae is low cost and high efficiency, and Kranuan has a low TE score. On the other hand, Khaosangkunag has a high TE score, and many of the middle cost hospitals have either a score of 1.0 or a very low score, thus making it very difficult to discern a pattern. The Pearson correlation coefficient of -0.409 confirms this finding.

Appendix 8 Figure 8.9 shows that the largest percentage reductions in average cost under the capacity use assumptions are for the two lowest cost hospitals, which is inconsistent with expectations. This suggests that low occupancy rates do not explain

high average costs. However, Khaosankuang has low occupancy rates, thus explaining higher average costs. Appendix 8 Figure 8.10 shows a scatter plot of inpatient average cost with hospital size, based on days per month optimal capacity. It is not possible to conclude from this evidence whether or not economies of scale exist from this data, with two lines drawn in an attempt to 'fit' the points. However, the Pearson correlation coefficient of -0.631 ($p < 0.05$) suggests that there is, in fact, a negative correlation.

7.1.2.4 Causes of inpatient care unit cost variation in South Africa

Appendix 8 Figure 8.11 shows that days per FTE are marginally lower in the wards with higher average cost. This suggests that the post-CS wards are either less intensively staffed, or they have higher occupancy, accounting for the lower average costs. Occupancy is lowest in wards E4 (postpartum-CS) and E5 (postpartum-VD), thus giving these wards a greater reduction in average cost under the 100% capacity assumption. However, as all wards are operating at over 80% average capacity, the recalculated average costs at 80% capacity are in fact higher than the original average costs. In general, wards with high average costs do not consistently have lower average occupancy. Also, the wards are a similar size, and therefore economies of scale are unlikely to be responsible for average cost differences. Case-mix data are not in a form that allows examination of the extent to which variations caused variations in average cost.

7.1.3 Delivery care

Table 7.4 shows that the average costs for vaginal delivery (VD) and caesarean section (CS) are significantly different in all countries. In Cuba, average costs are US\$21.32 and US\$113.98 respectively, in Thailand US\$27.225 and US\$83.00, in South Africa US\$81.40 and US\$140.60. Marginal costs in Cuba are US\$5.79 for VD and US\$43.54 for CS, averaging 27% (VD) and 38% (CS) of average cost. In Thailand, marginal costs vary between 20% of average cost for VD and 56% for CS, and in South Africa 7% and 18%.

Table 7.3: Average and marginal costs of delivery care in study countries.

COUNTRY and TYPE of CARE	Average cost				Marginal cost	
	Lower	Mean	Upper	COV	Mean	% AC
CUBA						
Vaginal delivery	16.45	21.32	26.20	0.24	5.92	0.28
Caesarean section	70.12	113.98	157.83	0.40	43.73	0.38
THAILAND						
Vaginal delivery						
Intervention average	24.44	31.75	39.07	0.42	7.35	0.23
Control average	19.57	22.75	25.93	0.25	3.73	0.16
Caesarean section						
Intervention average	-	67.05	-	-	40.32	0.60
Control average	-	98.95	-	-	51.95	0.52
SOUTH AFRICA						
Vaginal delivery	74.49	81.40	88.30	0.05	5.38	0.07
Caesarean section	105.71	140.60	175.48	0.16	24.91	0.18

Appendix 9 Table 9.3 shows that average costs for both VD and CS vary significantly between district hospitals, from US\$9.86 to US\$65.07 for VD (a difference of 660%) and from US\$39.04 to US\$185.10 for CS (a difference of 480%). Vaginal delivery has, not surprisingly, a lower unit cost in all countries compared with caesarean section, although the magnitude of difference differs between country. For example, vaginal delivery is under 20% the cost of CS in Cuba, but it is 57% the cost of CS in South Africa.

7.1.4 Discussion and conclusions

The analysis of costs has partly explained why such large differences were observed in unit costs between some health facilities. While significant differences were observed between individual health facilities, significant differences were not observed in unit costs between trial arms, thus suggesting that the W.H.O. antenatal care programme did not affect unit costs.

The efficient use of the most important resources, most notably staff for all countries, drugs for outpatient care in Cuba, and drugs and materials for caesarean section, was shown to have significant implications for average costs. For example, the ratio of visits or days per FTE, the technical efficiency score, and the presence of spare capacity, have been shown to influence average cost in some or most comparisons made. Economies of scale possibly exist in Cuban polyclinics for outpatient care, and for Thai hospitals for inpatient care. The impact of case-mix differences on unit costs could not be evaluated at an average level, although an additional drug cost could be calculated for an illness

treated on an individual patient level. There was mixed evidence whether clinics or wards treating high risk patients were higher cost than those treating low risk patients. Input mix variations were shown to be substantial between health facility, which remained largely unexplained by case-mix differences.

Three points should be noted here in interpreting the TE score results. First, TE scores were influenced heavily by staffing numbers, and therefore the results from this analysis and the previous analysis are not 'additive' (in that the results are largely based on the same data). Second, note that 'efficiency' is interpreted in relation to what the model inputs (staff and capital) and output (outpatient visits) are. Thus other potentially important inputs are missing, such as drugs and materials. Third, the TE scores obtained using monetary cost as inputs were different to those obtained in the last chapter. This is not surprising considering the inputs used are different: the inputs in this section include equipment costs, and the inputs were measured in money cost.

Results from the analysis of economies of scale should also be interpreted with caution. The most important point to note is that the size of clinic or ward was chosen at the maximum observed output during the study period, with no microeconomic study of the actual capacity levels. This affects comparability across health facilities, as they may operate at different levels of average capacity use. Also, economies of scale were assessed using visual inspection and the Pearson correlation coefficient, and regression techniques were not used; thus there could have been other factors responsible for the observed negative relationship between size and average cost in Cuban policlinics. The comparison of % contribution of overhead cost to average cost with health facility size did not reveal as significant results as the visual inspection and the Pearson correlation coefficient, and it is not clear how this difference can be interpreted.

The conclusions concerning causes of variation in marginal costs are less certain, because there is less variability between health providers, and because drug costs were obtained from a limited sample in Cuba and Thailand as opposed to the whole population of ANC attenders. In general, the greatest drug costs were from routine drugs and supplements, which were given to all women, and therefore there would exist minimum variability to examine.

7.2 Unit cost variations between countries

7.2.1 Sizes of cost variation

Table 7.4 summarises average costs (with 95% confidence interval) and marginal costs for all types of care in study countries, presented in US\$ using both nominal exchange rates and purchasing power parities. Comparisons of average costs using the 'F' test shows some significant and some non-significant results. These are discussed below.

Table 7.4: Summary of average and marginal costs in all countries.

TYPE of CARE and COUNTRY	Nominal exchange rate (US\$)					Purchasing power parity (US\$)			
	Average cost			Marginal cost		Average cost			MC
	Lower	Mean	Higher	Mean	% AC	Lower	Mean	Higher	Mean
OUTPATIENT ANC									
Primary health care									
Cuba	8.99	12.15	15.31	4.25	0.35	22.12	29.89	37.66	10.46
Thailand	4.70	6.19	7.69	1.41	0.23	9.14	12.03	14.95	2.74
South Africa	5.78	7.24	8.70	0.42	0.06	8.99	11.26	13.53	0.65
Secondary health care									
Cuba	2.82	3.22	3.62	0.64	0.20	6.94	7.92	8.91	1.57
Thailand	1.67	2.75	3.83	0.55	0.20	3.25	5.35	7.45	1.07
South Africa	7.47	9.05	10.62	0.95	0.11	11.62	14.07	16.51	1.48
INPATIENT CARE									
Low risk ANC									
Cuba	23.95	30.84	37.72	6.80	0.22	58.92	75.87	92.79	16.73
Thailand	5.54	6.56	7.58	0.97	0.15	10.77	12.75	14.74	1.89
South Africa	29.34	30.56	31.78	1.26	0.04	45.62	47.52	49.42	1.96
High risk ANC									
Cuba	39.37	51.72	64.07	10.39	0.20	96.85	127.23	157.61	25.56
Thailand	39.43	49.29	59.15	9.86	0.20	76.65	95.82	114.99	19.17
South Africa	27.24	33.13	39.02	1.51	0.05	42.36	51.52	60.68	2.35
Neonatal care									
Cuba	88.37	118.09	147.82	31.32	0.27	217.39	290.50	363.64	77.05
Thailand	13.12	16.41	19.69	3.28	0.20	25.51	31.90	38.28	6.38
South Africa	23.47	27.85	32.24	3.12	0.11	36.50	43.31	50.13	4.85
DELIVERY CARE									
Vaginal delivery									
Cuba	16.45	21.32	26.20	5.92	0.28	40.47	52.45	64.45	14.56
Thailand	19.17	27.25	35.34	5.39	0.20	37.27	52.97	68.70	10.48
South Africa	74.49	81.40	88.30	5.38	0.07	115.83	126.58	137.31	8.37
Caesarean section									
Cuba	70.12	113.98	157.83	43.73	0.38	172.50	280.39	388.26	107.58
Thailand ⁶⁷	58.1	83.00	107.9	46.74	0.56	113.4	161.35	209.3	90.86
South Africa	105.71	140.60	175.48	24.91	0.18	164.38	218.63	272.87	38.74

Average cost per outpatient visit was significantly less in Thailand (US\$6.19) and South Africa (US\$7.24) than Cuba (US\$12.15), at primary health care facilities. Marginal cost in Cuba was on average three times that in Thailand, and on average ten times that in

⁶⁷ The range on the average cost for CS in Thailand was predicted as +/- 30% of the mean (the variability from other countries was used).

South Africa. In referral facilities Cuba (US\$3.22) and Thailand (US\$2.75 and US\$2.10) were similar, and both were significantly less than South Africa (US\$9.04) ($p<0.05$). Marginal costs were a substantially lower proportion of average cost in South Africa. At PPP, outpatient ANC in Cuba⁶⁸ (US\$29.89) was even more expensive per visit than Thailand⁶⁹ (US\$12.04) and South Africa⁷⁰ (US\$11.26) than at nominal exchange rates.

Low risk inpatient antenatal care cost per day was similar in Cuba (US\$30.84) and South Africa (US\$30.56), and these were significantly more than in Thailand (US\$6.56). High risk inpatient antenatal care per day was more expensive in Cuba (US\$51.72) than in South Africa (US\$33.13). In Thailand, as the high risk care average costs were taken from a referral centre, average costs were much higher than low risk care, at US\$49.29. Marginal cost was a higher proportion of average cost in Cuba (20-24%) than Thailand (15%) and South Africa (4-14%). At PPP, Cuba was significantly more expensive than South Africa for low risk patients.

Finally, for delivery care, South Africa has the highest average costs at nominal exchange rates. For vaginal delivery, average cost per case in South Africa (US\$81.40) is significantly higher than Cuba (US\$21.32) and Thailand (US\$27.25). At PPP, these differences are smaller, but still significantly different from South Africa. For caesarean section, South Africa (US\$140.60) is significantly more than in Thailand (US\$83.00), but not significantly more than Cuba (US\$113.98). At PPP, Cuba and South Africa unit costs are higher than Thailand. In general, for all forms of care, where statistical significance exists, there is also economic significance. Even for the lowest cost form of care, outpatient visits, Thailand and South Africa are US\$5-6 less expensive than Cuba, which represents 68% (South Africa) and 96% (Thailand) of the cost of an outpatient ANC visit. For other forms of care statistically significant differences between country are at least 100% the average cost of an outpatient visit.

In summary, Cuba has the most expensive health services for most forms of maternity care at official exchange rates, and is even more expensive at PPP. South Africa has

⁶⁸ The PPP rate was US\$1=0.4065 Peso measured in 1998 (Appendix 4 Table 4.1).

⁶⁹ The PPP rate was US\$1=26.9 Baht measured in 1998 (Appendix 4 Table 4.1).

⁷⁰ The PPP rate was US\$1=3.17 Rand measured in 1998 (Appendix 4 Table 4.1).

comparable costs to Cuba for some forms of inpatient care, and delivery care. Thailand has the lowest cost care, except for inpatient care provided by referral facilities. The purpose of the following sub-sections is to explore the causes of difference in unit costs.

7.2.2 The impact of different prices on unit costs

The extent to which prices caused variations in average and marginal costs between countries is examined by comparing prices and unit costs across countries. Specifically, the inter-country average cost ratios are compared with the inter-country price ratios, at nominal exchange rates, to see whether they are similar. For example, if only prices are driving the cross-country differences, then the ratios would be the same. Table 7.5 below shows that salaries in Cuba were on average 74% of salaries in Thailand, and salaries in Cuba and Thailand were 19% and 25% of those in South Africa, respectively. Equipment and materials were, on average, more expensive in Cuba than Thailand, and more expensive in South Africa than Thailand. For example, electrical equipment was on average 75% higher in Cuba than Thailand, but furniture prices were comparable. Materials in Cuba were 80% more expensive than Thailand, and 69% more expensive than South Africa. However, these average differences mask large variability for individual items (see details in Appendix 11 Table 11.1).

Table 7.5: Price levels of resources and inter-country price ratios.

COUNTRY	TYPE OF RESOURCE				
	Staff	Electrical eq.	Furniture	Materials	Drugs
Relative prices (highest = 100)					
Cuba	19	54	72	100	100
Thailand	25	31	72	56	59
South Africa	100	100	100	87	22
Price ratios					
Cuba/Thailand	0.74	1.75	1.00	1.80	1.69
Cuba/South Africa	0.19	0.54	0.72	1.15	4.55
South Africa/Thailand	3.98	3.27	1.39	1.56	0.37

Figure 7.8 shows variations in salaries between health professionals within as well as between country, at nominal exchange rate and PPP. For all categories of staff, South Africa is the most costly country, although at PPP inter-country differences are reduced.

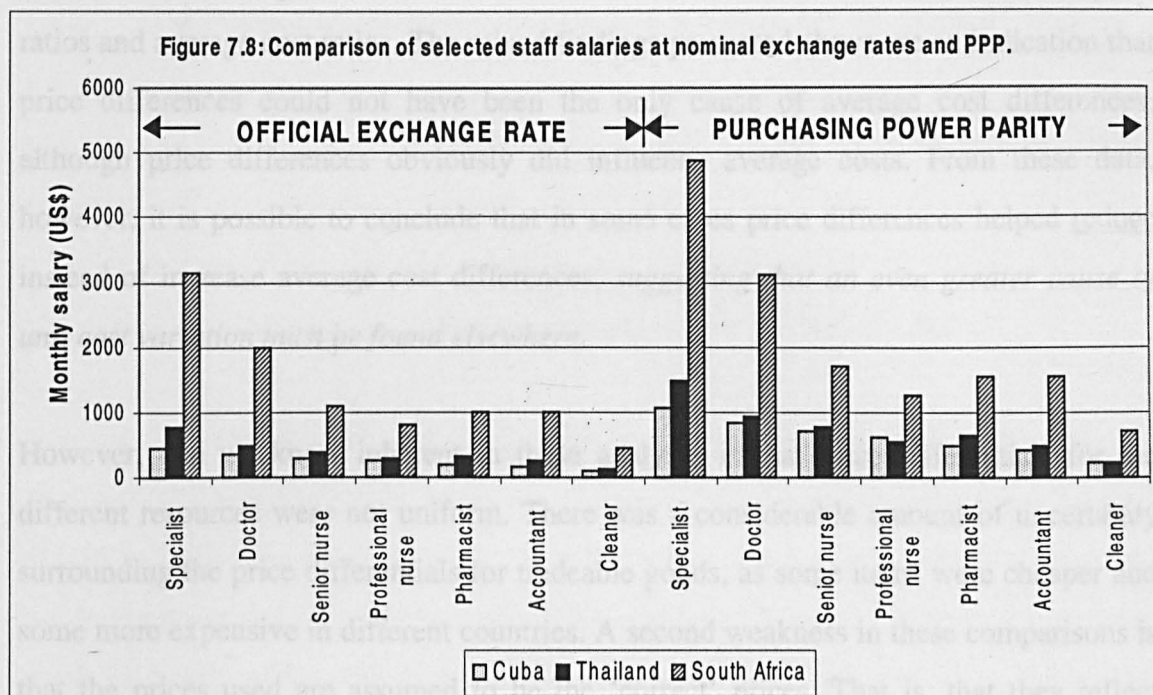


Table 7.6 shows percentage differences in average cost between Cuba, Thailand and South Africa. Almost all average costs in Cuba exceeded those in Thailand: by 96% for outpatient ANC, 470% for inpatient antenatal care, 37% for CS, and by 720% for neonatal care. Normal vaginal delivery, on the other hand, is 28% more expensive in Thailand than Cuba. However, these variations do not appear to have been caused directly by consistently higher prices in Cuba, as salaries, which take the largest share of unit cost, are lower in Cuba. While average costs of outpatient ANC were comparable between Thailand and South Africa, inpatient care in South Africa was more similar to Cuban unit costs. Other major differences between countries were vaginal delivery, which was more than 300% greater in South Africa than in Cuba and Thailand, and neonatal care was 424% higher in Cuba than South Africa.

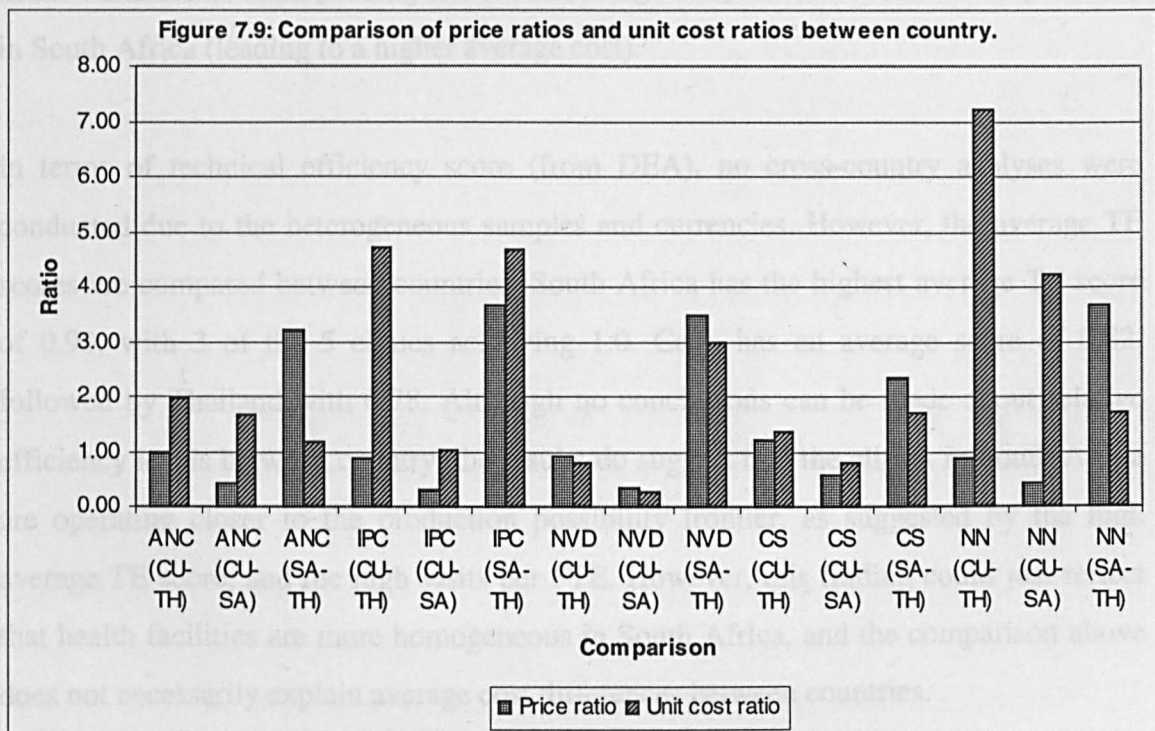
Table 7.6: Unit costs of health services and inter-country unit cost ratios.

COUNTRY COMPARISON	TYPE OF HEALTH CARE				
	Outpatient antenatal care	Inpatient antenatal care	Vaginal delivery	Caesarean section	Neonatal care
Unit cost ratios					
Cuba/Thailand	1.96	4.71	0.78	1.37	7.20
Cuba/South Africa	1.68	1.01	0.26	0.81	4.24
South Africa/Thailand	1.17	4.67	2.99	1.69	1.70

Figure 7.9 illustrates the findings discussed above. It is clear from a comparison of ratios that price differences alone were not responsible for differences in average cost,

based on the finding that there was limited correlation in cross-country resource price ratios and average cost ratios. The mixed findings presented above are an indication that price differences could not have been the only cause of average cost differences, although price differences obviously did influence average costs. From these data, however, it is possible to conclude that in some cases price differences helped reduce instead of increase average cost differences, *suggesting that an even greater cause of unit cost variation must be found elsewhere.*

However, one weakness inherent in these analyses is that price differentials for the different resources were not uniform. There was a considerable amount of uncertainty surrounding the price differentials for tradeable goods, as some items were cheaper and some more expensive in different countries. A second weakness in these comparisons is that the prices used are assumed to be the 'correct' prices. That is, that they reflect opportunity cost. A related point is that the two exchange rates used are assumed to reflect the full range of variation possible in exchange rates, which might not be the case. These issues are explored later in this chapter, in the sensitivity analysis.



7.2.3 The impact of different resource quantities on unit costs

7.2.3.1 Causes of cross-country unit cost variation in outpatient ANC

The following analysis seeks to explain why average costs per outpatient visit in primary providers in Cuba were almost twice those in Thailand and South Africa, and why South Africa was three times the cost of Cuba and Thailand in referral centres. Also, the causes of large cross-country differences in marginal costs are also sought.

Average numbers of visits per FTE are in fact very similar between Cuba (89) and Thailand (97), while in South Africa the average is 314. However, the average member of staff in Cuba is more highly trained than the other countries, indicated by the fact that the doctor:nurse and obstetrician:nurse ratios are higher. Therefore, despite higher wage levels in South Africa, the fact that nurses are the main care providers has a cost-decreasing effect. Also, staff in South Africa are relatively productive in terms of the number of visits per FTE. The different average costs at referral centres are partly explained by the fact that visits per FTE of 284 are higher in referral than in primary health facilities in Cuba (leading to a lower average cost) and lower (143 visits per FTE) in South Africa (leading to a higher average cost).

In terms of technical efficiency score (from DEA), no cross-country analyses were conducted due to the heterogeneous samples and currencies. However, the average TE scores are compared between countries. South Africa has the highest average TE score of 0.93, with 3 of the 5 clinics achieving 1.0. Cuba has an average score of 0.82, followed by Thailand with 0.78. Although no conclusions can be made about relative efficiency levels between country, the results do suggest that the clinics in South Africa are operating closer to the production possibility frontier, as suggested by the high average TE score, and the high visits per FTE. However, this finding could just reflect that health facilities are more homogeneous in South Africa, and the comparison above does not necessarily explain average cost differences between countries.

The large inter-month variation in outpatient visits in Cuba and Thailand suggest that, on average, few health facilities are operating on their frontier much of the time, although they may reach it for several months per year. An important cause of this is

that demand for ANC is variable, as shown by variation in month to month throughput (although no seasonal trends were observed).

Differences in average occupancy rates between country did not provide evidence for why Cuba is more costly than other countries. Average costs in policlinics in Cuba were on average only 13% above their potential average cost of US\$10.52, whereas in Thailand the average was 34% (potential average cost of US\$4.07), and in South Africa the average was 27% (potential unit cost of US\$5.78). Therefore the smallest average reduction in average cost was observed in Cuba under the assumption of full capacity.

Appendix 9 Tables 9.4-9.6 show the contribution of each resource to average cost for all types of care. The data show evidence of significant variation both between and within countries for outpatient care. The proportion of staff cost in Cuba averaged 58% (between 50-73% for all policlinics), while in Thailand it averaged 66% (range 54-76%), and South Africa it averaged 88% (range 86-91%). The proportion of equipment cost averaged under 0.5-2% in Cuba and South Africa, and 7% in Thailand. The proportion of material cost in Cuba averaged 1%, South Africa 2%, and Thailand 9%. The proportion of drug cost in Cuba averaged 34%, in Thailand 13%, and in South Africa under 3.2%. Finally, utilities and buildings contributed 2-4% to average cost in primary facilities in all countries, but tended to be higher in referral facilities (e.g. utilities 8% and buildings 12% in Prince Mshiyeni hospital). The causes of these variations between country can only be speculated. For example, the relatively low staff contribution in Cuba was due to the high drug cost, caused not by high prices faced on the international market but also more intensive usage than the other countries (which was concluded in Chapter 6). In Thailand more was spent on equipment and materials, but less on drugs, utilities and buildings, relative to Cuba. This was because Thai hospitals are relatively well resourced in terms of equipment lists and material supplies. South Africa had lower US\$ cost and lower % contribution from non-staff items because there are very few resources in the clinics (equipment) and because these other resources were very cheap compared to staff.

The very different staffing ratios (doctor:nurse ratios) in the three countries in shown Table 7.7 indicate that the production functions were highly flexible in terms of staff

input. For example, in Cuba outpatient care is provided by obstetricians and doctors on a one-to-one basis, whereas in Thailand and South Africa outpatient ANC was mainly nurse-based, and uses a production line system. One possible reason for the differences in ratios (staff:staff and staff:patient) was that higher trained staff in Cuba were not significantly more expensive than less trained staff. For example, doctors earned on average 40% more than nurses in Cuba, whereas the difference was more in Thailand (67%) and South Africa (250%).

Table 7.7 also shows the ratio between a month's salary and various tradeable goods. In Cuba equipment, materials and drugs are relatively expensive. The relatively high cost of imported goods leads to two possible reactions – either there is no substitution and no change in demand for these items with a subsequently high contribution to average cost, or there is a reduction in demand for imported items. From the resource data collected, it appears that in Cuba there was no reduction in demand for drugs, but there was for materials and equipment. In contrast to the situation in Cuba, equipment, materials and drugs in South Africa were relatively cheap compared to salaries, leading to a low contribution of equipment cost (<1%), as well as low material and drug costs for most forms of care. Hence this suggests a relatively inflexible production function, as there was little substitution away from staff. The relatively high costs of equipment and drugs in Thailand, however, does not result in low contributions (>6% for equipment and >14% for drugs for ANC).

Table 7.7: Relative prices and staff ratios for selected resources in study countries.

Doctor:resource	Price ratio			Number of staff ratio (primary)		
	Cuba	Thailand	South Africa	Cuba	Thailand	South Africa
Doctor:professional nurse	1.40	1.67	2.50	1.05	0.11	0
Doctor:specialist	0.78	0.63	0.64	0.29	0	0
Doctor:admin worker	2.06	1.93	2.00	3.37	0.64	0
Health care staff:admin worker	-	-	-	7.9	6.26	3.9
Doctor:computer	0.18	0.62	1.28	-	-	-
Doctor:microscope	0.09	0.25	0.40	-	-	-
Doctor:1000 litre detergent	0.19	0.92	1.56	-	-	-
Doctor:1000 soap	0.66	3.68	20.00	-	-	-
Doctor:10,000 paracetamol	1.75	4.78	41.67	-	-	-
Doctor:10,000 folic acid	1.17	9.96	25.00	-	-	-
Doctor:10,000 metronidazol	0.47	4.78	30.30	-	-	-

In conclusion, from these data presented, few similarities existed between countries concerning resource use ratios and % resource costs: low or high relative prices did not

consistently lead to higher or lower % contribution to average costs, but behaviour varies between countries.

The impact of case-mix differences between countries on health service use has already been examined earlier, and data were provided in Appendix 5 Tables 5.2 and 5.3 for the three study countries. Data presented earlier in this chapter on risk factors showed Cuba to be a higher risk country. This was largely due to higher parity, making it more likely that women have risk factors. It is likely, though cannot be proved precisely, that differences in case-mix influenced the resource use intensity, and thus the unit costs, in each country. For example, the higher risks and the higher rates of adverse event during pregnancy in Cuba were likely to be part of the cause of higher per visit drug costs there. For example, bleeding, sexually transmitted diseases, hypertensive diseases of pregnancy and urinary tract infection are higher in Cuba than Thailand. Therefore, the resource intensity of the health system in Cuba probably partly reflects the ability to diagnose and treat the relatively higher number of risk cases. For example, every polyclinic had between 2 and 4 full time obstetricians, and over 50 medical doctors, compared to zero obstetricians and under 6 doctors in Thailand in the district hospitals, which have a similar throughput of outpatients (both general and ANC). The high rates of adverse outcome during pregnancy in South Africa is not reflected in resource use in health centres, but more in high referral rates, visits at secondary hospital, and inpatient admission.

7.2.3.2 Causes of cross-country unit cost variation in inpatient care

This section seeks to explain why inpatient costs in Cuba and South Africa are similar, when prices have been shown to be so different between these countries. Also, the section seeks to explain why inpatient care is considerably more expensive in Cuba and South Africa than Thailand.

In Cuba, the number of days per FTE in the adult wards average 34 in Cuba, 37 in South Africa, and 71 in Thailand. Therefore Cuba and South Africa are similar in staffing efficiency, and Thailand is on average about twice as 'efficient'. These data therefore explain part of the difference in average costs between Cuba/South Africa and Thailand. Operating at below capacity caused average costs in Cuban adult wards to be on average 17% above their potential average cost. In Thailand, the average was 30% above the

potential average cost of US\$4.7, and South Africa the average was between 4-10% above the potential average costs. Therefore, if anything, the lack of exploitation of full capacity levels caused unit costs to be closer, on average, than they would have been if all providers were operating at 100% capacity.

Ward sizes (bed numbers) are similar in Cuba and South Africa, and relatively smaller in Thailand. Therefore, it is unlikely that economies of scale could have explained average costs differences between these countries. Input mix differences have already been discussed above, under the 'outpatient ANC' section. Differences are not quite so marked for inpatient care, with staff taking around 70% in Cuba and Thailand, and 75-80% in South Africa. The staff contribution in Cuba is higher for inpatient than outpatient care, due to lower drug contribution. Equipment proportions are 5-7% in Cuba and Thailand, but under 1% in South Africa. The remaining resources contribute similar shares in all countries.

Case-mix differences in inpatient care are difficult to link with average cost, as there are limited data on severity of diseases or events. Information on the average length of stay and bed turnover rates is not used, as they are poor predictors of severity difference between countries as medical practice was shown to differ significantly. Appendix 6 Figure 6.3 showed occupancy plotted against turnover rate. A low ALOS and average cost in Thailand was thought to be due to a relatively light case-mix, as these are primary care hospitals with no specialist support. This is supported by the fact that secondary level inpatient care in Thailand is significantly more costly, on a par with average cost per day of Cuba and South Africa (see Appendix 9 Table 9.2). Case-mix is similar between Cuba and South Africa, giving further cause for similar average costs.

7.2.4 Costing methods and uncertainty

Uncertainty is present to some degree in these costing studies. Due to differences in the way clinics are organised to provide antenatal care, and differences in the quality of data systems and data availability, the standardised top-down costing approach was tailored to each country (for example, see the step-down allocation method used in Cuba in Appendix 4 Table 4.2). Also, the divergence between financial cost and opportunity cost may have been different in the three study countries. Therefore, the purpose of this

section is to examine whether systematic differences in unit cost may have been caused by the choice of one set of costing methods over another.

Sources of uncertainty were listed in the methods chapter, and a preliminary assessment made of which were the most likely to affect unit cost. For those sources that could be tested and that were expected to have a potentially large impact on average costs, likely ranges or alternative values were identified, and average costs recalculated based on these ranges. In the absence of stochastic data at the patient level, some sources of uncertainty were not amenable to statistical or probabilistic testing, and it was concluded that simple sensitivity analysis (one-way and multi-way) would be used to test the impact of uncertainty on average costs.

7.2.4.1 One-way sensitivity analysis

International costs of equipment

Appendix 9 Table 9.10 shows average costs when equipment costs are adjusted to reflect the scenario in which world market prices increase by 50%. The results show that the greatest impact is on the average costs of VD (increased 10%) and CS (5%) in Thailand, and for neonatal care (4%) in South Africa. In Cuba, the impact is under 2% for all types of care. However, the ranges were within the 95% confidence interval for all forms of care, thus suggesting average costs are sufficiently robust to this form of uncertainty.

Change in cost of tradeable goods

Appendix 9 Table 9.10 shows the average cost results when the cost of all tradeable goods (all equipment, materials and drugs) are increased by 50%, to reflect possible fluctuations in world prices. The greatest overall impact was in Cuba, where the impact is greater than 13% for all types of care. The biggest single impact was in Thailand, where the cost of CS increases by 37%, which is outside the 95% confidence interval of the base case average cost. The smallest impacts were in South Africa, where salaries made up the largest share of average cost. The results show that average costs were relatively robust to changes in the costs of tradeable goods. However, the impact on marginal cost was greater, as tradeable goods constitute 100% of marginal cost. Thus an increase in the prices of all tradeable goods by 50% would also lead to an increase in marginal costs of 50%. However, as some tradeable goods are not imported, the actual

impact of such as increase in the price of tradeables would be less than that reported here.

Length of life of capital items

Appendix 9 Table 9.10 shows the average cost results when the length of life of capital goods is halved and doubled. Average costs are shown to be relatively unaffected by this assumption, varying up to 14% when equipment length of life is doubled, and up to 28% when halved. However, the average impact was much less. Again, the greatest impact was in Thailand, where equipment were a larger share of average costs for ANC (7%, compared to 1% in Cuba and South Africa). Thus inpatient care and vaginal delivery average costs were not robust, as the sensitivity analysis range is outside the 95% confidence interval.

Alternative value for wages

Appendix 9 Table 9.10 shows the average cost results when wage costs are increased by the average differential between public and private sector wages in Thailand and South Africa (to reflect a likely upper value for the opportunity cost of staff, because the public sector has to 'compete' with the private sector). In Cuba, the 50% increase reflects to some degree the nature of the communist economy, where wages do not take into account additional benefits, such as rations and housing. As expected, the large share of salaries in average costs resulted in significant impact on average costs, varying between 28% and 44% (although CS was only 9% in Thailand, as the staff contribution was low). The highest increases were recorded in South Africa, with an average of 41%. In conclusion, average costs are not robust to changes in staff costs.

Use of average drug cost

Appendix 9 Table 9.11 shows average costs for outpatient ANC in Cuba and Thailand based on pooled drug cost for each arm. The biggest impacts were in Romay (16% increase), Manduley (11% increase) and Galvan (11% decrease) in Cuba, and Puvient (14% increase) and Khaosangkuang (8% decrease) in Thailand. However, the inter-health facility differences are likely to represent real as opposed to artificial differences, due to differences in the rates of illness experienced in different health facilities.

Simultaneous step-down cost allocation

Appendix 9 Table 9.12 shows the average cost results when simultaneous step-down cost allocation was used instead of one-way step-down cost allocation. The potential inaccuracy of not using simultaneous step-down cost allocation was taken from a previous study, with an estimated inaccuracy of +/- 20% for allocated costs. Allocated costs are defined as all costs *excluding* direct costs and laboratory costs, the proportion of which is shown in the first column. The impact on average cost was consistently close to 5% change from the base average cost. The greatest impact on average cost was +/- 8% of unit cost, for CS in Cuba, while the smallest impact was for CS in South Africa, which had an impact of +/- 1%. Considering that the 20% inaccuracy used is likely to be a high overestimate of the inaccuracy likely in practice, this area of uncertainty is unlikely to have much impact on average costs.

Alternative exchange rates

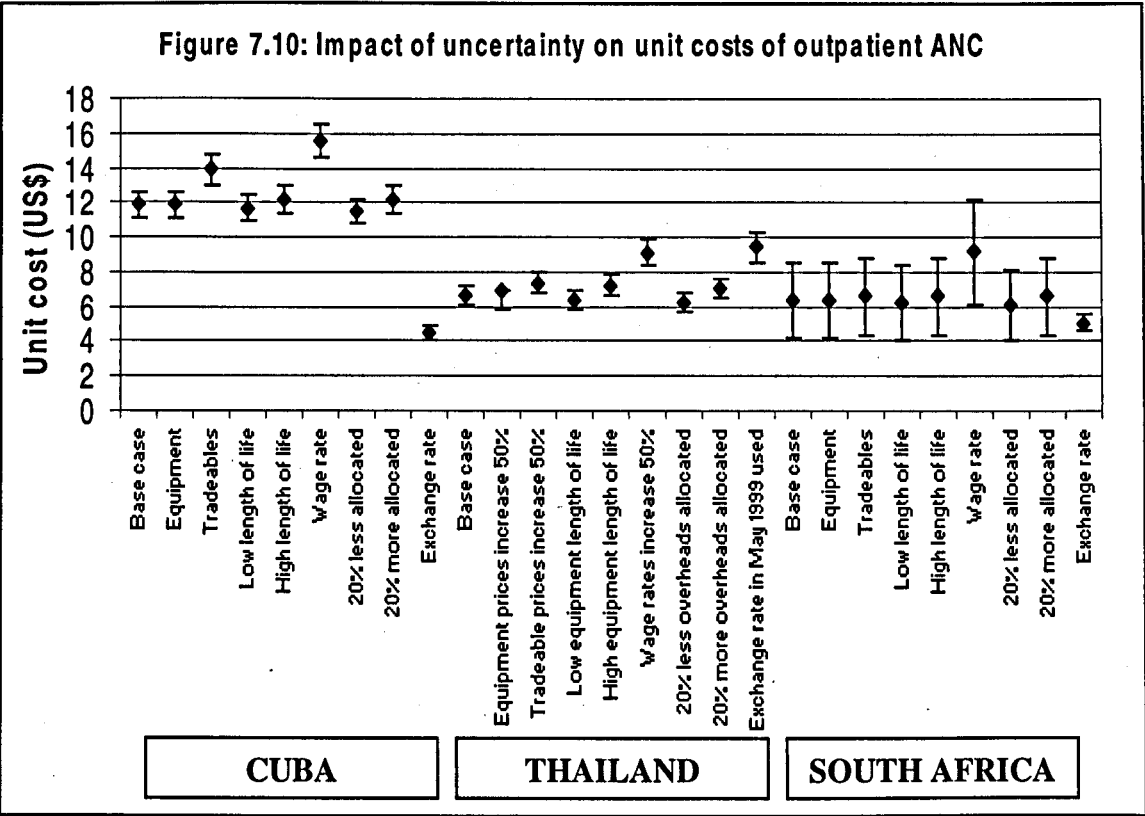
Appendix 9 Table 9.12 shows data on average costs when alternative exchange rates were used. For all countries and all types of care, the impact on average costs was large, and very few costs were robust to the ranges used. The biggest impact was in Cuba, where average cost was reduced by around 70%. This is because the value of non-traded goods on the international market are worth only 1/20th the original value (using the approximate black market exchange rate of US\$1 = 20 Cuban Pesos). In Thailand, average costs were 42% higher (due to the appreciation of the exchange rate) and in South Africa the average costs were 21% lower (due to the depreciation of the exchange rate).

Uncertainty due to small number of months

Appendix 9 Table 9.13 shows the impact of using differences in average cost from using a moving average of four and eight months in Thailand, to reflect the uncertainty of having only eight months data in Cuba and only four months data in South Africa. In Cuba, this had an impact of between 7-12%; while in South Africa, the impact was between 8-26%. These data indicate that using 8 months of average cost data instead of 15 months in Cuba did not have a great impact on the accuracy of average costs, whereas in South Africa it did have.

Conclusions

Some sources of potential uncertainty clearly had a large impact on average costs, while others had a less significant effect. Figure 7.10 summarises the sensitivity analysis results, showing clearly that the biggest impacts on average costs of antenatal care in Cuba were the exchange rate for non-tradeable goods (reducing unit cost), and the alternative wage rate (increasing unit costs). Similarly in Thailand, the biggest impacts were alternative values for exchanges rates and wages. In South Africa, the biggest impact was the alternative wage rate, whereas all the other sources of uncertainty did not have a major effect. The impact of small number of months on unit cost in Cuba and South Africa are not shown in the figure, but the impact on average costs in South Africa were the most significant.



7.2.4.2 Multi-way sensitivity analysis

Table 7.15 below shows the impact on unit costs of the multi-way sensitivity analysis at 1998 OER, taking into account several areas of uncertainty simultaneously⁷¹. The areas of uncertainty combined are:

- Adjustment of the value of tradeable goods (T in Table 7.8) by 50%,
- Adjustment of the value of staff costs (W in Table 7.8) by 50%,
- Halving and doubling of the length of life of capital items (C in Table 7.8), and
- The impact of data collection over a small number of months (M in Table 7.8).

The overall adjustment factor for average costs is presented in the 'ALL' column, for both the high and low estimates. For the high estimate, the factor is remarkably consistent between country and type of health care, at around 60% (between 56% and 78%), while for the low estimate, the factor was less consistent, ranging between a reduction of 5% and 28% (most values 10-20%). Therefore, in the later section when cost per pregnancy is recalculated based on these ranges, for simplicity all unit costs are increased by 60% for the high estimate, and reduced by 20% for the low estimate⁷².

Implications for inter-country differences are significant, as some of the differences that were found to be highly significant before are reduced to almost non-significant levels. For example, the lower confidence limit from the sensitivity analysis for outpatient ANC in Cuba (US\$10.9) almost overlaps with the high estimate for Thailand (US\$10.3) and South Africa (US\$10.2). Also, postpartum care cost per day is no longer significantly different between Cuba (upper limit US\$27.6) and South Africa (lower limit US\$23.3), and CS in Thailand (upper limit US\$120.5) now overlaps with Cuba (US\$99.2) and South Africa (US\$101.2).

⁷¹ It assumes that the four sources of uncertainty included are 'additive' in terms of their impact on cost.

⁷² The crudity of this method was justified in that these factors were only approximations anyway.

Table 7.8: Impact on average costs of multi-way sensitivity analysis, with average cost range and % change.

Health care	Country	Average cost			High estimate						Low estimate			
		Low	Base	High	T	W	C	M	ALL	NEW	C	M	ALL	NEW
		US\$	US\$	US\$	%	%	%	%	%	US\$	%	%	%	US\$
Antenatal care	Cuba	11.1	11.9	12.6	0.17	0.31	0.03	0.07	0.58	18.8	0.01	0.07	0.08	10.9
	Thai	6.1	6.6	7.2	0.10	0.37	0.09	0.00	0.56	10.3	0.05	0.00	0.05	6.3
	S.Africa	4.2	6.4	8.5	0.03	0.44	0.04	0.08	0.59	10.2	0.02	0.08	0.10	5.8
Inpatient care	Cuba	23.9	30.8	37.7	0.13	0.35	0.04	0.08	0.60	49.3	0.02	0.08	0.10	27.7
	Thai	5.7	6.2	6.7	0.11	0.35	0.12	0.00	0.58	9.8	0.06	0.00	0.06	5.8
	S.Africa	29.3	30.6	31.8	0.02	0.41	0.07	0.16	0.66	50.8	0.03	0.16	0.19	24.8
Vaginal delivery	Cuba	16.4	21.3	26.2	0.16	0.30	0.05	0.12	0.63	34.7	0.03	0.12	0.15	18.1
	Thai	20.6	23.1	25.5	0.17	0.28	0.28	0.00	0.73	40.0	0.14	0.00	0.14	19.9
	S.Africa	74.5	81.4	88.3	0.03	0.41	0.07	0.17	0.68	136.8	0.03	0.17	0.20	65.1
Caesarean section	Cuba	70.1	114.0	157.9	0.20	0.29	0.02	0.12	0.63	185.8	0.01	0.12	0.13	99.2
	Thai	n/a	74.4	n/a	0.37	0.09	0.16	0.00	0.62	120.5	0.08	0.00	0.08	68.4
	S.Africa	105.7	140.6	175.5	0.10	0.37	0.05	0.26	0.78	250.3	0.02	0.26	0.28	101.2
Postpartum care	Cuba	13.9	16.8	19.6	0.14	0.33	0.05	0.12	0.64	27.6	0.03	0.12	0.15	14.3
	S.Africa	22.6	27.7	32.8	0.07	0.38	0.07	0.12	0.64	45.4	0.04	0.12	0.16	23.3
Neonatal care	Cuba	96.7	118.1	139.5	0.16	0.32	0.05	0.12	0.65	194.9	0.03	0.12	0.15	100.4
	S.Africa	23.5	27.9	32.2	0.09	0.35	0.14	0.16	0.74	48.5	0.07	0.16	0.23	21.5

Figures in bold means that the AC range is larger than the lower or higher confidence limits

However, the presence of uncertainty does not impact other inter-country differences in average costs. For example, inpatient ANC cost per day is still significantly lower in Thailand, vaginal delivery is still significantly higher in South Africa, and cost per neonatal day is still significantly higher in Cuba. Also, in interpreting the confidence limits of the sensitivity analysis results, it should be taken into account that the upper limits of one country and unlikely to occur simultaneously as the lower limits in another country, as only the extreme scenarios are tested. These extremes are unlikely to occur in reality, but at least they give an estimate of the outer limits of average costs. In conclusion, the presence of uncertainty between country is unlikely to reduce the inter-country differences in average costs greatly.

7.2.5 Discussion and conclusion

This section discusses some of the results and issues raised in the second half of this chapter, on cross-country unit cost comparisons and causes of variation. The data analysis in the cross-country comparison was different to the within-country comparison for several reasons. First, relative efficiency using DEA could not be calculated for the cross-country comparison, due to the problems of comparing costs in US\$ after conversion from different local currencies. Second, case-mix and quality of care differences were possibly an important source of cross-country unit cost difference; however, neither of these were properly evaluated, although some conclusions were

made about their likely influence on unit costs. For example, the high visits per nurse FTE, as well as anecdotal evidence, suggest that outpatient ANC at the clinics in South Africa may not have been as high quality as in Cuba and Thailand, where on average more time was devoted to caring for each woman. Third, price and costing method differences were more important to examine in the cross-country comparisons.

The cross-country comparisons suffered other constraints. For example, resource use comparisons between the three countries were constrained by the fact that the specifications of these resources varied between countries. For example, while FTE had the appearance of a generic measure, it hides differences in which staff comprise the full-time equivalent staff (nurse, doctors, obstetricians, or even non-health care personnel such as patient helpers in Thailand). Also, when making cross-country resource price comparisons, average prices for groups of resources were compared, and the matching process (e.g. drugs or equipment) was deemed to be far from perfect. Finally, the cross-country comparisons of cost using the 95% confidence intervals calculated from month to month variability suffers the same problems in interpretation of 'significant' differences discussed earlier. If these confidence intervals do not represent true variability, then the conclusions of significant differences are weakened. On the other hand, differences between US\$ values between country are considerable for many of the cross-country comparisons, and therefore suggests analysis of variation is justified to explore what caused these differences.

While bearing these facts in mind, some significant findings arose from the cross-country cost comparisons and cost analyses. It was found that, on the whole, price differentials between country (either relative or absolute prices) were not responsible for unit cost variations, and in some cases they even reduced the differences that would have been observed if prices had been uniform across countries. Using purchasing power parities for currency conversion to US\$ did not reduce the cross-country differences in unit costs; in fact, their use increased the differences, as the greatest change in US\$ value occurred in Cuba, which was already the highest cost country.

Differences in visits and days per FTE between countries were found to be consistent with unit cost differences, in that those countries with the lower ratios had the higher

unit costs, for all types of care. Cuba was the most intensive user of labour, followed by Thailand for outpatient care, and by South Africa for inpatient care. Cuba was also the most intensive user of drugs, and combined with the fact that Cuba faced high drug prices on the international market meant that the drug cost contribution to average cost was higher than the other countries. Therefore, unit cost differences were more due to staff productivity and drug prescription differences than price differences. Equipment costs were found to be highest in referral centres; equipment lists were minimal in family doctor clinics in Cuba and health centres in South Africa, and therefore contributed very little to average costs.

The use of sensitivity analysis to explore the impact of uncertainty in key variables was found to increase the ranges on average costs, significantly in some cases, such as alternative assumptions about wage rates, and alternative exchange rates. In some cases, allowance for uncertainty reduced the differences in average costs between countries to the point where some unit cost ranges overlapped. Also, uncertainty may have been greater in some countries for certain variables. For example, price uncertainty was considerable in Cuba, such as the wage rate that represented the opportunity cost; and the ranges chosen in sensitivity analysis may not have covered the entire range possible. Also, there was considerable uncertainty surrounding the true Cuban Peso: US\$ exchange rate, as it was thought that the official exchange rate of 1:1 overvalued the Cuban Peso, as suggested by black market rates. When using the black market exchange rate of US\$1:20 Cuban Pesos for non-tradeable goods, there were large reductions in Cuban unit costs when converted to US\$.

8 CAUSES OF VARIATION IN COST PER PREGNANCY

The aim of this chapter is to identify and explain variations in cost per pregnancy, and is the final stage of cost analysis before cost prediction methods are tested. The first section identifies statistically significant variations in cost per pregnancy between trial arms, health facilities, and countries. Cost analyses are divided into three further sections. In section 8.2, cost per pregnancy variations are examined in terms of the extent to which they are caused by (a) variations in health service use and (b) variations in unit cost. In section 8.3, the cost per pregnancy of women with different risk factors and events are compared, using 2-way tabulations, to identify which appear to explain differences in cost per pregnancy. In section 8.4, multiple regression analyses are performed to identify predictors of cost per pregnancy, also using the results of previous sections and chapters to build the model. Section 8.5 concludes.

8.1 Size and significance of cost per pregnancy variations

8.1.1 Cost per pregnancy results

8.1.1.1 Cost per pregnancy in Cuba

Table 8.1 below shows the base case results of cost per pregnancy (CPP): the average and marginal CPP for women attending each health facility with 95% confidence intervals, and median CPP. In Cuba, the mean average cost per pregnancy (ACPP) at the polyclinic level ranged from US\$298 to US\$504 in the intervention arm (average US\$372) and from US\$369 to US\$447 in the control arm (average US\$401). The difference of US\$29 between trial arms was not statistically significant at the 95% level (95% confidence interval for the difference -US\$2.46 to US\$62.52). This finding is confirmed when using log cost to calculate the 95% confidence interval of the difference. However, to become statistically less expensive in the intervention arm, only 0.2 visits less per woman would be required in the intervention arm (to 7.30 visits per woman), which is a possibility as this value is only just outside the lower 95% confidence interval of 7.36 visits per woman. A statistically significant difference would have also been concluded if the CS rate in the intervention arm had been 21.7% instead of 22.7%. The incremental cost of US\$29 using average cost equalled 2.5 antenatal care visits, and therefore was economically meaningful. For no difference to exist in cost per

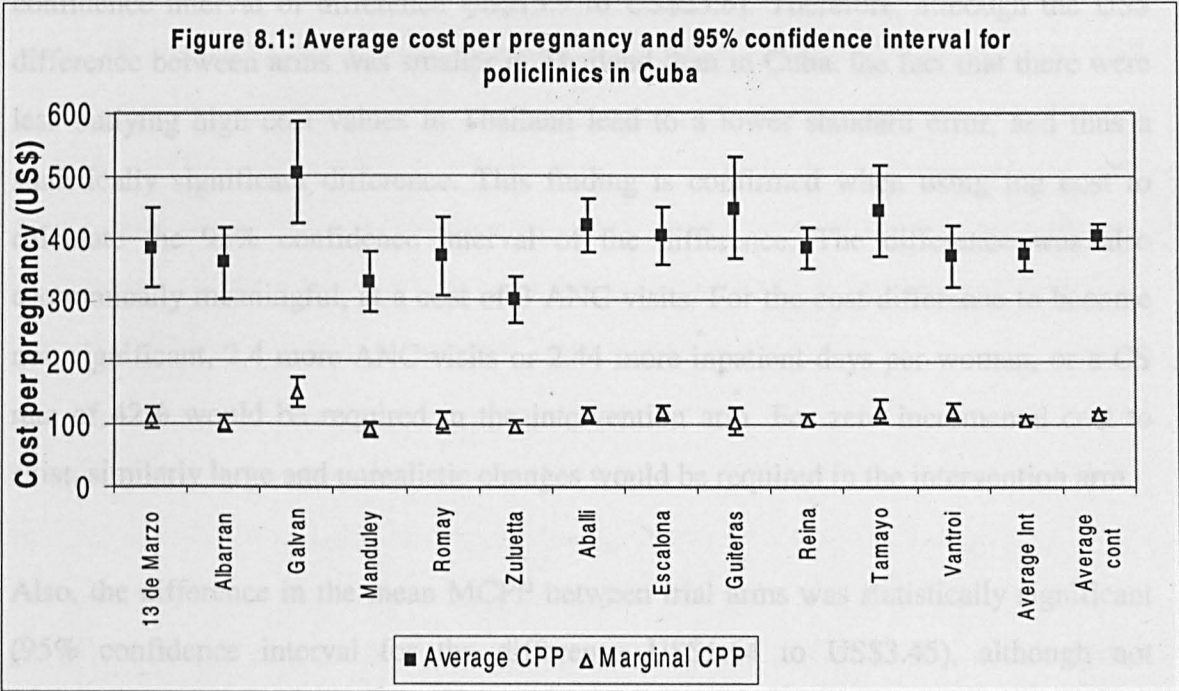
pregnancy between trial arms, numbers of ANC visits per woman would have had to increase to 10.0 from 7.50, or one more inpatient day per woman, or a CS rate of 42.7%, none of which are likely (in the trial population). Similarly, there was no difference in marginal cost between trial arms (95% confidence interval of -US\$1.44 to US\$4.34). The difference in cost per pregnancy using marginal cost amounted to roughly 0.58 antenatal care visits, and therefore was not economically significant.

Table 8.1: Average and marginal cost per pregnancy in study countries.

Country and health care provider	Cases		Average cost per pregnancy (US\$)					Marginal cost per pregnancy (US\$)					
	No.	%	Mean				Med	Mean				Med	
			Low	Mean	High	SE		Low	Mean	High	SE		
CUBA													
13 de Marzo	449	8.0	317.1	382.4	447.7	33.3	178.8	92.65	109.92	127.19	8.81	58.4	
Albarran	567	10.1	298.7	357.3	415.9	29.9	189.7	85.84	99.96	114.08	7.21	57.7	
Galvan	459	8.2	421.2	504.4	587.5	42.4	255.2	128.90	151.27	173.65	11.42	88.0	
Manduley	575	10.3	277.8	325.8	373.8	24.5	161.4	81.85	93.54	105.23	5.96	53.3	
Romay	418	7.5	304.9	369.3	433.6	32.8	156.8	86.22	103.23	120.24	8.68	45.5	
Zuluetta	402	7.2	261.6	298.1	334.6	18.6	162.4	88.60	98.74	108.88	5.17	59.2	
<i>Average Intervention</i>	2870	51.2	346.9	371.9	396.9	12.8	181.8	102.27	108.74	115.22	3.30	59.2	
Aballi	514	9.2	376.5	419.6	462.7	22.0	243.9	104.92	116.72	128.51	6.02	67.5	
Escalona	628	11.2	354.5	401.4	448.2	23.9	187.8	106.61	119.28	131.94	6.46	60.9	
Guiteras	177	3.2	366.4	447.2	527.9	41.2	302.5	83.43	104.86	126.28	10.93	63.4	
Reina	648	11.6	347.0	382.0	417.0	17.9	241.7	99.38	108.35	117.31	4.57	70.4	
Tamayo	294	5.2	368.8	442.0	515.3	37.4	267.0	102.42	121.58	140.74	9.77	72.9	
Vantroi	473	8.4	317.6	368.8	419.9	26.1	187.4	107.18	120.98	134.79	7.05	72.3	
<i>Average control</i>	2734	48.8	381.5	401.9	422.4	10.4	240.8	110.36	115.81	121.27	2.78	68.6	
Difference	-	-	-2.46	30.03	62.52	16.6	59.0	-1.44	7.07	15.58	4.34	9.4	
Log difference	-	-	-0.67	1.477	3.626	1.10	-	-	-	-	-	-	
THAILAND													
Chumpae	1001	15.7	63.0	68.4	73.8	2.8	39.4	19.63	20.80	21.98	0.60	14.4	
Banphai	729	11.4	109.6	115.9	122.2	3.2	87.1	29.39	30.93	32.46	0.78	25.2	
Phuwiang	558	8.8	62.2	65.1	67.9	1.5	54.1	9.18	9.87	10.55	0.35	6.4	
Manjakiri	476	7.5	74.5	77.8	81.1	1.7	70.1	11.37	12.34	13.31	0.50	9.3	
Khaosuankwang	306	4.8	92.1	100.8	109.5	4.4	78.2	21.53	23.27	25.01	0.89	18.7	
Waeng Noi	208	3.3	107.4	113.9	120.4	3.3	104.0	16.78	18.62	20.47	0.94	13.2	
<i>Intervention average</i>	3278	51.5	83.1	85.7	88.2	1.3	67.9	19.44	20.1	20.67	0.3	15.6	
Kranuan	821	12.9	102.4	106.3	110.2	2.0	96.6	23.55	24.50	25.44	0.48	21.5	
Nongsonghong	323	5.1	75.6	87.3	98.9	5.9	46.8	16.77	19.32	21.86	1.30	10.3	
Phol	630	9.9	128.1	136.1	144.1	4.1	95.7	22.02	23.84	25.65	0.93	13.5	
Nongrua	400	6.3	105.2	114.5	123.8	4.7	70.1	22.81	24.93	27.06	1.08	14.6	
Srichompoo	595	9.3	66.4	69.4	72.3	1.5	67.3	16.85	17.64	18.44	0.41	16.3	
Nampong	322	5.1	105.1	117.5	129.9	6.3	91.2	22.11	25.11	28.12	1.53	17.8	
<i>Control average</i>	3091	48.5	102.5	105.5	108.6	1.6	80.4	21.93	22.6	23.31	0.4	16.3	
Difference	-	-	15.9	19.86	23.8	2.01	12.5	1.64	2.57	3.45	0.47	0.7	
Log difference	-	-	1.07	1.301	1.53	0.117	-	-	-	-	-	-	
SOUTH AFRICA													
Prince Mshiyeni	785	100	323.7	347.0	370	11.9	214	37.4	41.1	44.8	1.87	20.8	

Figure 8.1 below shows clearly the inter-policlinic differences in ACPP and MCPP. The size of standard error indicates significant variability in cost per pregnancy in most

health facilities⁷³, as well as indicating statistically significant ACPP differences between policlinics (e.g. Zulueta versus Galvan), although the studentised ‘t’ test was done to show statistically significant differences⁷⁴. The median CPP values were lower than the mean CPP values, because of the positive skewness of the cost data. Table 8.1 shows that the median ACPP in the intervention arm (US\$182) was US\$59 less than that of the control arm (US\$219), which was economically significant.



Appendix 12 Table 12.1 shows that the greatest contributor to cost per pregnancy was antenatal care – an average of 24% in the intervention arm and 36% in the control arm. Other contributors were postpartum care (22-24%), neonatal care (18-22%) antenatal inpatient care (10-13%), and delivery care (11%). On the whole, there was consistency between policlinics within each arm, although some differences between providers emerged (e.g. Guiteras policlinic has very high outpatient ANC costs, at 49% of ACPP). Staff was the highest resource contributor to CPP in Cuba (61%), followed by drugs (20%), materials (10%), and equipment, utilities and buildings combined taking 9%.

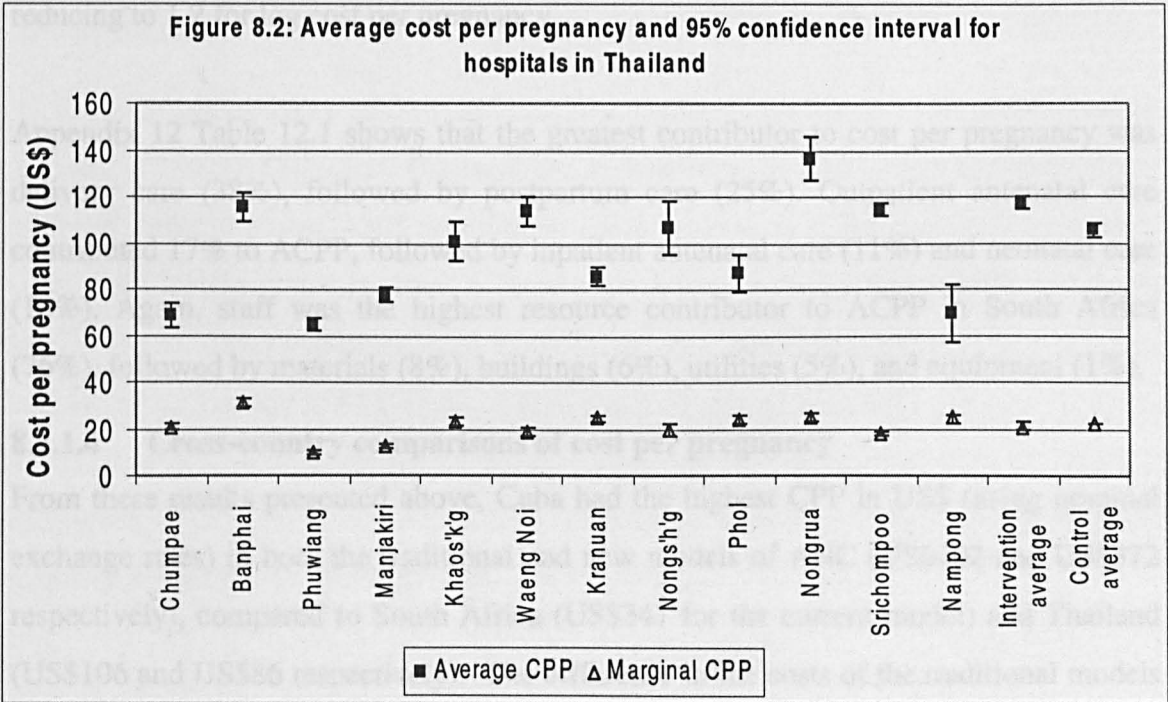
⁷³ This variation was partly caused by the fact that women who had CS and neonates who were admitted to the intensive care unit were substantially more costly, thus causing a bimodal distribution.

⁷⁴ This test allows for the skewed nature of the dependent variable cost per pregnancy. The measure of skewness for the 12 policlinics varied between 4.2 and 8.4; however, when log cost per pregnancy was used, the measure of skewness reduced to 1.3 to 2.1. A value of greater than 1 indicates a non-normal distribution.

8.1.1.2 Cost per pregnancy in Thailand

Table 8.1 shows the cost per pregnancy results for Thailand, and Figure 8.2 shows clearly the inter-hospital differences in ACPP and MCPP. The mean ACPP in the 12 participating district hospitals ranged from US\$65 to US\$116 in the intervention arm (average US\$86) and from US\$69 to US\$136 in the control arm (average US\$105). This difference of US\$20 between arms was statistically significant at the 95% level (95% confidence interval of difference US\$15.9 to US\$23.8). Therefore, although the US\$ difference between arms was smaller in Thailand than in Cuba, the fact that there were less outlying high cost values in Thailand lead to a lower standard error, and thus a statistically significant difference. This finding is confirmed when using log cost to calculate the 95% confidence interval of the difference. The difference was also economically meaningful, at a cost of 3 ANC visits. For the cost difference to become non-significant, 2.4 more ANC visits or 2.44 more inpatient days per woman, or a CS rate of 42% would be required in the intervention arm. For zero incremental cost to exist, similarly large and unrealistic changes would be required in the intervention arm.

Also, the difference in the mean MCPP between trial arms was statistically significant (95% confidence interval for the difference US\$1.64 to US\$3.45), although not economically significant. The median ACPP in the intervention arm (US\$67.9) was US\$12.5 less than that of the control arm (US\$80.4)(economically significant). The median MCPP was US\$0.7 more in the control arm (not economically significant).



The measure of skewness varied for cost per pregnancy between 2.1 and 9.4 in the district hospitals, reducing to between -1.3 and 2.1 for log cost per pregnancy. Appendix 12 Table 12.1 shows that the greatest overall contributor to cost per pregnancy was antenatal care – an average of 32% in the intervention arm and 42% in the control arm. Other contributors were delivery care (36% and 29%), postpartum care (29% and 26%), neonatal care (3% and 2%), and inpatient antenatal care (1% in both arms). On the whole, there was consistency between hospitals within arm in terms of % contribution, although some differences between hospitals also emerged (e.g. Kranuan had a high ANC cost of 52%, and Sichompoo had a low postpartum care cost of 11%). Again, staff was the highest resource ingredient, contributing 67% to ACPP, followed by materials (11%), drugs (9%), and equipment (8%), buildings (4%) and utilities (2%). There was also some variation between hospital in these rates.

8.1.1.3 Cost per pregnancy in South Africa

Table 8.1 shows that the ACPP in South Africa was US\$347, with a 95% confidence interval of US\$324 to US\$370. The median CPP was US\$214. The range in ACPP for individual women was very large, from US\$140 to US\$3,800. The MCPP was US\$41.10 with a 95% confidence interval of US\$37.4 to US\$44.8. The median MCPP was US\$20.8. Inter-hospital differences are not measured in South Africa, as the entire sample was drawn from one hospital, and women are not distinguishable by which clinic they attended ANC. The measure of skewness for cost per pregnancy was 3.3, reducing to 1.2 for log cost per pregnancy.

Appendix 12 Table 12.1 shows that the greatest contributor to cost per pregnancy was delivery care (38%), followed by postpartum care (25%). Outpatient antenatal care contributed 17% to ACPP, followed by inpatient antenatal care (11%) and neonatal care (10%). Again, staff was the highest resource contributor to ACPP in South Africa (76%), followed by materials (8%), buildings (6%), utilities (5%), and equipment (1%).

8.1.1.4 Cross-country comparisons of cost per pregnancy

From these results presented above, Cuba had the highest CPP in US\$ (using nominal exchange rates) in both the traditional and new models of ANC (US\$402 and US\$372 respectively), compared to South Africa (US\$347 for the current model) and Thailand (US\$106 and US\$86 respectively). The difference in the costs of the traditional models

between Cuba and South Africa of US\$55 was statistically significant. However, both countries were significantly more expensive than Thailand. In terms of economic differences, ACPP in Cuba was about 50 ANC visits more expensive than in Thailand (at Thai average cost per ANC visit), and marginal cost about 15 ANC visits more expensive. Similarly, ACPP in Cuba was about 9 ANC visits more expensive than in South Africa (at South African average cost per ANC visit), and marginal cost about 12 ANC visits more expensive. Thus Cuba was significantly more expensive than Thailand and South Africa, at nominal exchange rates.

Table 8.2 below shows the same comparisons using PPP values, which resulted in even greater costs in Cuba compared to Thailand and South Africa. ACPP in Cuba averaged US\$951, in South Africa US\$540, and Thailand US\$285. MCPP was by far the greatest in Cuba (US\$146 to US\$169) while in Thailand and South Africa they were similar at around US\$30-US\$33.

Table 8.2: Cost per pregnancy (average and marginal) using purchasing power parity.

Health care provider unit	Average cost per pregnancy (US\$)					Marginal cost per pregnancy (US\$)				
	Mean				Median	Mean				Median
	Low	Mean	High	SE		Low	Mean	High	SE	
CUBA										
Average Intervention	853.3	914.8	976.4	31.4	447.2	251.6	267.5	283.4	8.1	145.7
Average control	938.4	988.7	1039.0	25.7	592.3	271.5	284.9	298.3	6.8	168.9
THAILAND										
Average Intervention	161.6	166.5	171.5	2.5	132.0	37.8	39.0	40.2	0.6	30.3
Average control	199.2	205.1	211.0	3.0	156.3	42.6	44.0	45.3	0.7	31.7
SOUTH AFRICA										
Average control	503.4	539.6	575.8	18.5	332.5	58.2	63.9	69.7	2.9	32.3

SE – standard error

In terms of contributors to cost per pregnancy, there were many differences between countries. In both Cuba and Thailand, the contribution of ANC costs not surprisingly reduced under the new ANC programme (36% to 24% in Cuba and 42% to 32% in Thailand). Delivery care received a larger proportion in Thailand (29-36%) and South Africa (about 38%) compared with Cuba (11%), but inpatient ANC and neonatal care received significantly less in Thailand (1% each) compared with 16% and 20% in Cuba, and 11% and 10% in South Africa. Staff consistently took the largest share of ACPP in all countries, ranging from 61% to 76%. There were also some differences in resource contribution shares to ACPP, with drugs most significant in Cuba.

8.1.2 Impact of uncertainty on cost per pregnancy comparisons

Chapter 7 examined the impact of uncertainty on average costs, and found that this uncertainty reduced the extent to which cost differences between countries were statistically different. This section uses the ranges on average costs obtained in the sensitivity analysis to calculate new ranges on cost per pregnancy, to examine whether further or fewer differences between countries emerge. Table 8.3 presents new upper and lower confidence limits, taking into account the average cost range from the multi-way sensitivity analysis.

Table 8.3: Cost per pregnancy ranges using results from sensitivity analysis and alternative currency conversion methods.

CURRENCY CONVERSION METHOD and COUNTRY/ARM	Average cost per pregnancy (US\$)			Marginal cost per pregnancy (US\$)		
	Mean			Mean		
	Low	Mean	High	Low	Mean	High
NOMINAL EXCHANGE RATE (January 1998)						
Cuba						
Average Intervention	277.5	371.9	635.0	81.8	108.7	184.4
Average control	305.2	401.9	675.8	88.3	115.8	194.0
Thailand						
Intervention average	66.5	85.7	141.1	15.6	20.1	33.1
Average control	82.0	105.5	173.7	17.5	22.6	37.3
South Africa						
Average control	259.0	347.0	592.4	29.9	41.1	71.7
PURCHASING POWER PARITY						
Cuba						
Average Intervention	682.6	914.8	1562.2	201.3	267.5	453.5
Average control	750.7	988.7	1662.4	217.2	284.9	477.3
Thailand						
Intervention average	129.3	166.5	274.4	30.2	39.0	64.3
Average control	159.4	205.1	337.6	34.1	44.0	72.5
South Africa						
Average control	402.7	539.6	921.2	46.5	63.9	111.5
NOMINAL EXCHANGE RATE (May 1999)¹						
Cuba						
Average Intervention	108.7	135.9	217.4	86.2	107.81	172
Average control	115.8	144.7	231.5	93.1	116.43	186
Thailand						
Intervention average	94.5	121.7	200.6	22.1	28.5	47.0
Average control	116.5	150.0	246.8	24.9	32.2	53.0
South Africa						
Average control	205.6	275.5	470.3	23.8	32.6	56.9

¹ For Cuba, the black market rate of US\$1 = 20 Pesos is applied to non-traded goods.

Results are presented at nominal exchange rates in January 1998, purchasing power parity in January 1998, and nominal exchange rates in May 1999. The lower confidence limit reflects both stochastic variability (minus 2 standard errors of the mean) and deterministic variability (20% reduction in cost). The upper confidence limit likewise

reflects stochastic variability (plus 2 standard errors of the mean) and deterministic variability (60% increase in cost).

At both 1998 nominal exchange rates and PPP, the ACP results still show Thailand to have significantly lower costs than in Cuba and South Africa. However, at 1999 nominal exchange rates, costs in Thailand increased dramatically compared to Cuba and South Africa, which both experienced a decrease. Intervention arm costs in Thailand were only US\$14 less than in Cuba (worth the value of two ANC visits in Thailand). At OER and PPP, marginal costs were significantly greater in Cuba compared to the other countries, but Thailand and South Africa were no longer significantly different. Using 1999 nominal exchange rates, the difference between control arm in Thailand and South Africa was reduced to non-significance. However, costs did not change in Cuba using marginal costs as the exchange rate with the US\$ remained at 1:1. In conclusion, the tabulation of ranges on cost per pregnancy using unit cost values from sensitivity analysis caused a decrease in some CPP variations to non-significance. Also, the use of 1999 nominal exchange rates (and black market rates for Cuba) had a significant impact on the results, making Cuba relatively less costly, and Thailand relatively more costly.

8.2 Main causes of cost per pregnancy variation

This section examines the relationship between health service use, unit costs, and cost per pregnancy, to explain why cost per pregnancy varied between trial arms, individual health facilities, and countries.

8.2.1 Cost per pregnancy variation between trial arms

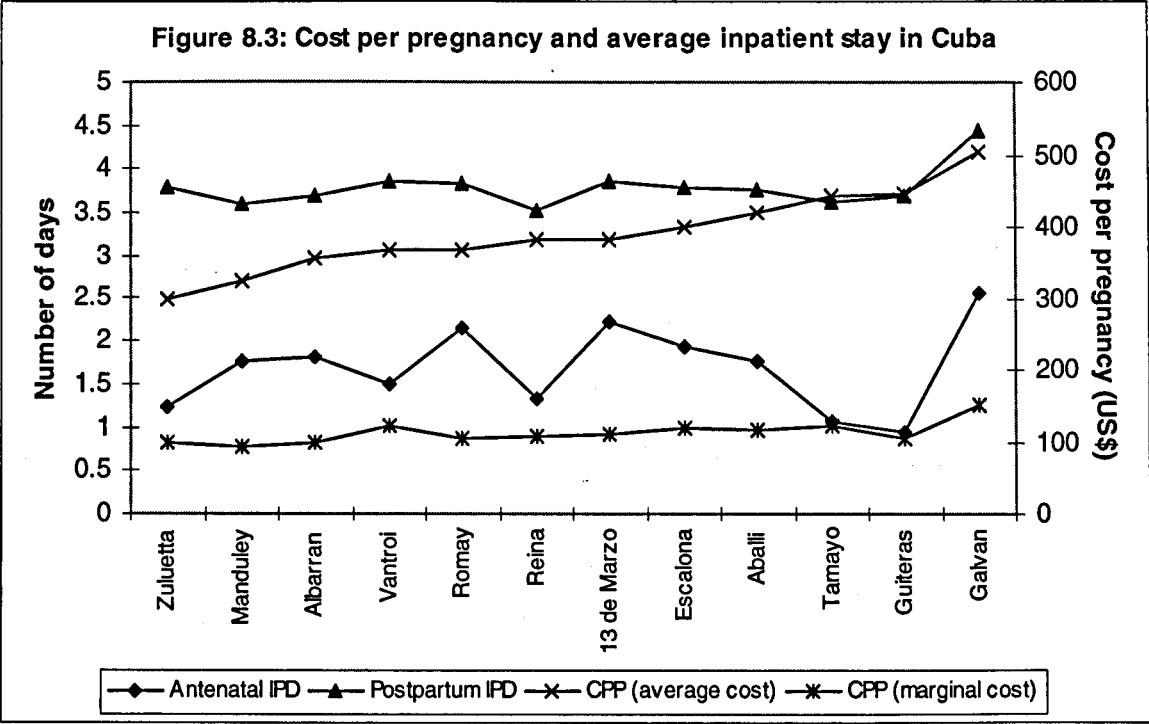
The conclusions of the previous two chapters showed that some types of health service use varied between trial arms in Cuba and Thailand, but unit costs did not vary systematically between trial arms. In Cuba, the reduction in ACP was US\$29. However, with a reduction in the average ANC visits of 5.6, *ceteris paribus* the expected saving would be US\$68, using the overall policlinic average cost of US\$12.15. This reduction was not achieved due to greater use of other health services, including an average of 0.42 inpatient days longer during pregnancy and 0.1 neonatal days longer per baby born, in the intervention arm.

In Thailand, with a reduction of 2.7 visits per woman in the intervention arm, the expected reduction of US\$17.5 was close to the actual reduction of US\$19.9. However, this similarity masked other small differences between trial arms in terms of use and unit costs of other health services, including CS unit costs, CS rates, and postpartum average length of stay (see Table 6.3).

8.2.2 Cost per pregnancy variation between health facilities

8.2.2.1 Cost per pregnancy variation between health facilities in Cuba

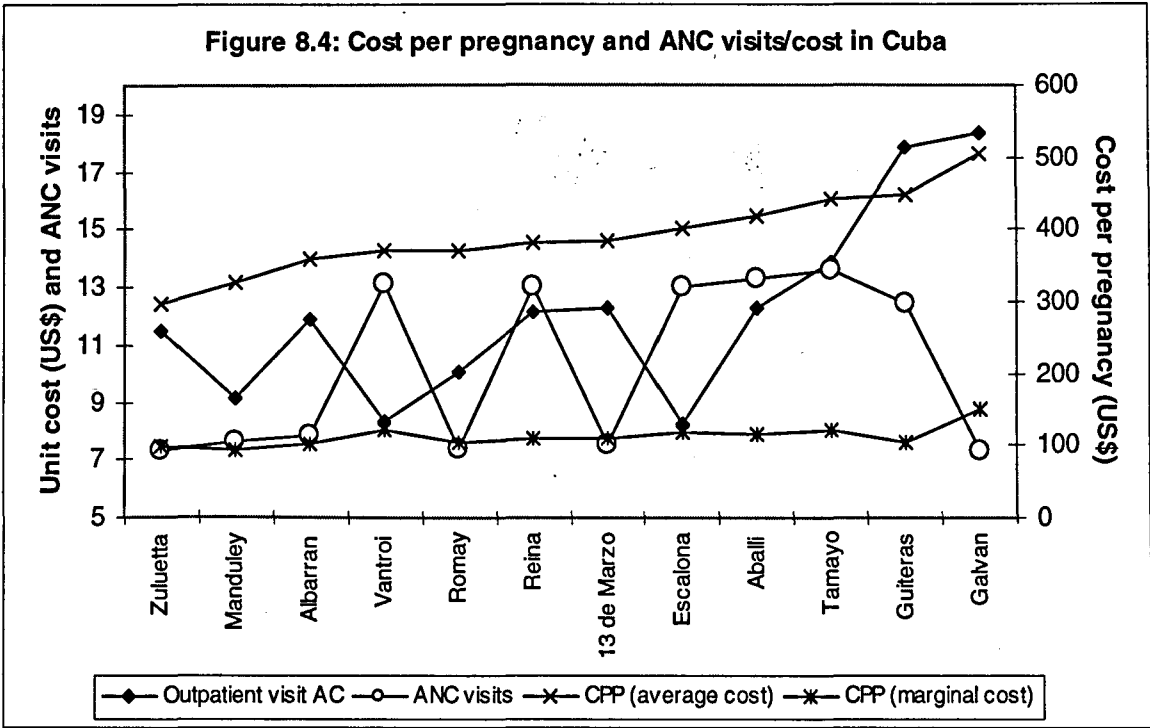
The cost per pregnancy variation between policlinics within arm must be explained by identifying variations in health service use or unit cost. Figure 8.3 below shows the variation in antenatal and postpartum days between policlinics, compared with ACPP and MCPP.



The high ACPP and MCPP in Galvan were partly explained by high average inpatient days, as well as neonatal days (1.17 per neonate). On the other hand, there was no discernible pattern amongst the other policlinics: the ones with high ACPP did not tend to have more IPD per trial woman. Zulueta may have had a low ACPP because of low antenatal IPD. Therefore, it appears that health service use only partially explained cost per pregnancy differences in Cuba.

Figure 8.4 shows that intervention arm policlinics, with less visits per woman, did not have consistently lower ACPP than control policlinics. For example, Galvan was in the

control group, and had the highest ACPP. The reason for this is that ANC is relatively low cost compared to other types of maternity care, and therefore rates of other HSU were also important determinants of CPP. High average costs for ANC may have contributed to Galvana nd Guiteras having high CPP, although the effect of average cost did not appear to be strong for other policlinics.



8.2.2.2 Cost per pregnancy variation between health facilities in Thailand

Figure 8.5 below shows the variation in antenatal and postpartum days between hospitals, compared with ACPP and MCPP. There appeared to be no strong relationship between average days per woman and ACPP or MCPP. The low CPP in Sichompoo was partly due to the low rates of health service use for all types of care by women there, especially postpartumm stay. In Chumpae, there was a higher postpartum IPD than the average, but ACPP was low.

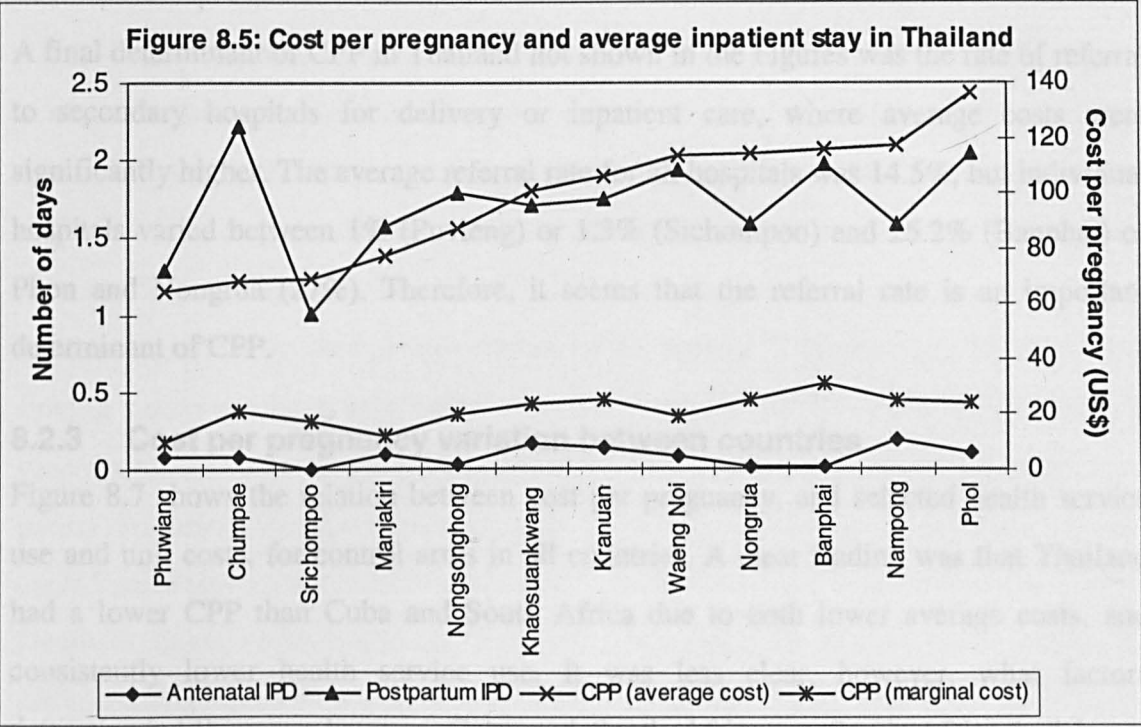
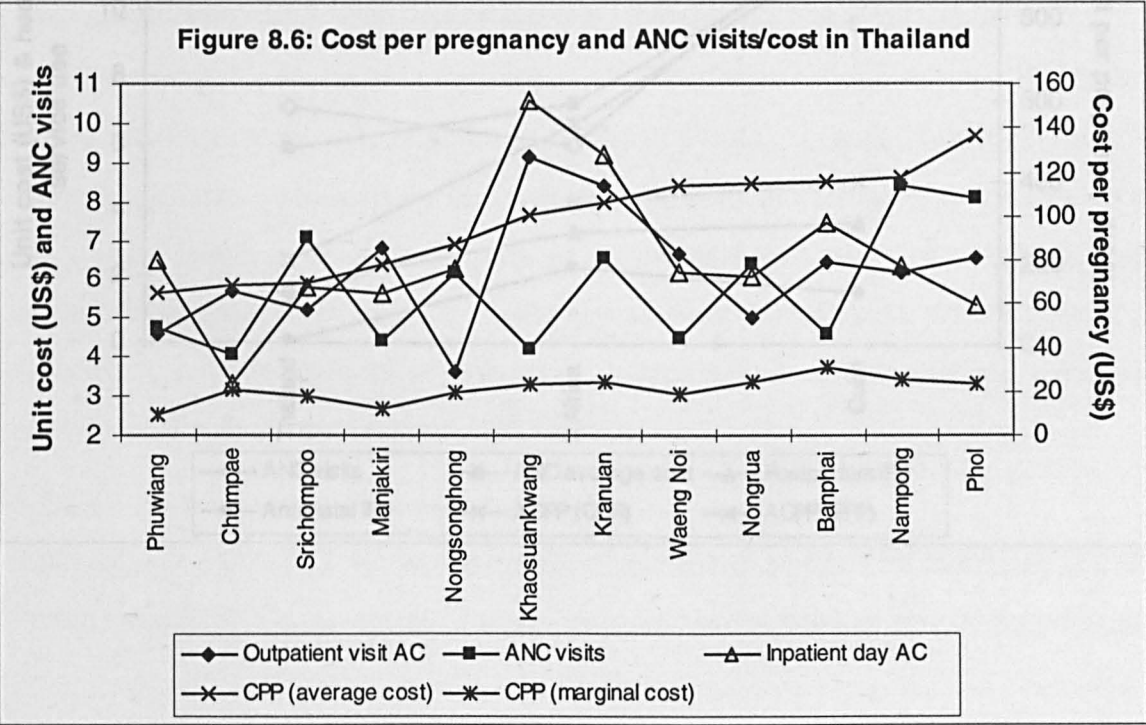


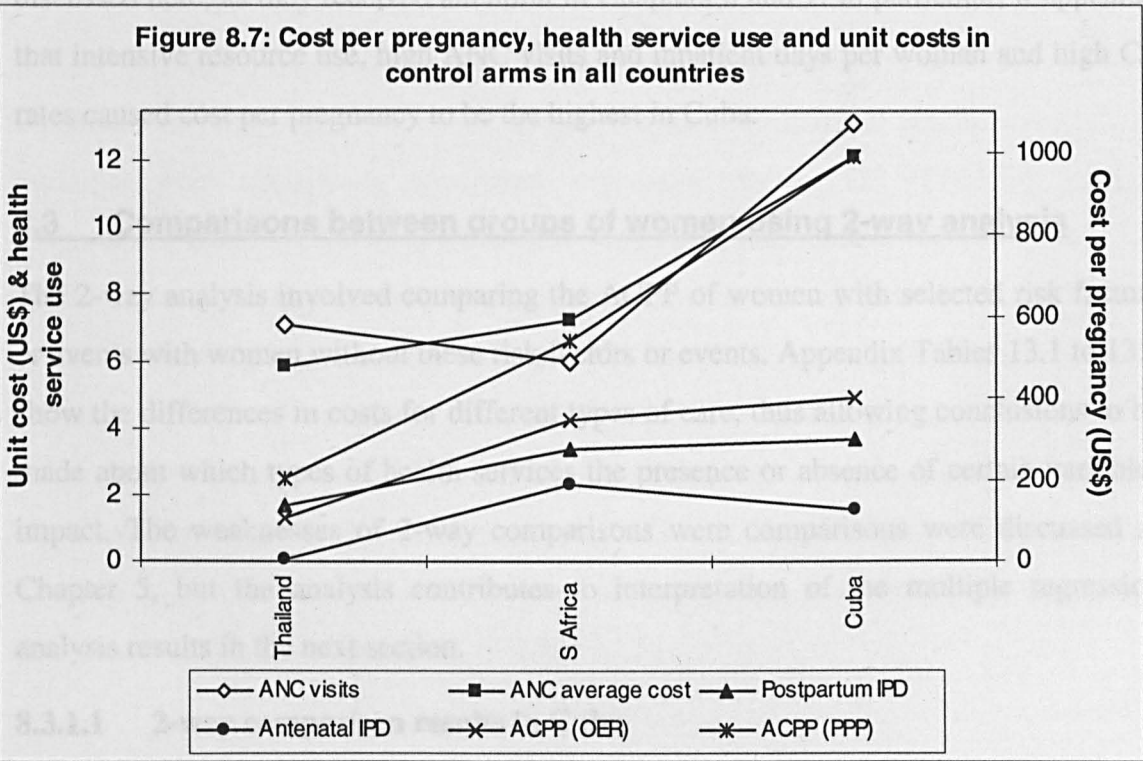
Figure 8.6 shows limited correlation between outpatient visits and average cost with the ACPP and MCPP. Using visual inspection the high ACPP in Phon was partly explained by the high ANC visits and high average cost for CS (not in Figure), but average costs of ANC and other health service use measures were in the middle range. Nampong also had high ANC visits and ACPP, but other indicators were in the middle range. Also, two hospitals with high average costs (Khaosankuang and Kranuan) only had middle-range ACPP. The causes of the low CPP in Phuwieng and Chumpae were not apparent from these Figures.



A final determinant of CPP in Thailand not shown in the Figures was the rate of referral to secondary hospitals for delivery or inpatient care, where average costs were significantly higher. The average referral rate for all hospitals was 14.5%, but individual hospitals varied between 1% (Puvieng) or 1.3% (Sichompoo) and 25.2% (Banphai) or Phon and Nongrua (27%). Therefore, it seems that the referral rate is an important determinant of CPP.

8.2.3 Cost per pregnancy variation between countries

Figure 8.7 shows the relation between cost per pregnancy, and selected health service use and unit costs, for control arms in all countries. A clear finding was that Thailand had a lower CPP than Cuba and South Africa due to both lower average costs, and consistently lower health service use. It was less clear, however, what factors determined differences between Cuba and South Africa, as South Africa had lower health service use and unit costs for some activities, but higher for others. For example, CS rates and adult inpatient days were similar across Cuba and South Africa, neonatal days were higher and had lower cost per day in South Africa, delivery care was more expensive in South Africa, and ANC visits were higher in Cuba.



8.2.4 Conclusion

A few conclusions are made from the results of this section, and implications drawn. *First*, differences in cost per pregnancy between arm in both Cuba and Thailand were due to differences in health service use, mainly in the numbers of ANC visits, and average days of inpatient stay (both ANC and postpartum). Average costs did not increase significantly through introduction of the new ANC programme. Therefore, this finding would not be generalisable to countries where the average costs of maternity care would increase with the introduction of the new ANC programme. For example, in poorly resourced settings implementation of the recommended model would require considerable investment in health services. *Second*, there were large differences between health facilities in both health service use and unit costs, which were jointly driving the differences in cost per pregnancy. However, in neither country were all intervention providers lower cost per pregnancy than control providers. This finding has important implications for prediction of costs of the new antenatal care programme in these countries. *Third*, the differences in cost per pregnancy between country were due to significant differences in both average costs (at both nominal exchange rates and PPP) and health service use. The causes of differences in HSU and unit costs are not discussed here, as they received attention in Chapters 6 and 7. In particular, it appeared that intensive resource use, high ANC visits and inpatient days per woman and high CS rates caused cost per pregnancy to be the highest in Cuba.

8.3 Comparisons between groups of women using 2-way analysis

The 2-way analysis involved comparing the ACPP of women with selected risk factors or events with women without these risk factors or events. Appendix Tables 13.1 to 13.3 show the differences in costs for different types of care, thus allowing conclusions to be made about which types of health services the presence or absence of certain variables impact. The weaknesses of 2-way comparisons were comparisons were discussed in Chapter 5, but the analysis contributes to interpretation of the multiple regression analysis results in the next section.

8.3.1.1 2-way comparison results in Cuba

Appendix 13 Table 13.1 shows the results of the 2-way analysis for Cuba, on selected dummy variables. The complete data set, broken down by arm and with 95% confidence

intervals, is provided in Appendix 13 Table 13.4. Those differences that were statistically significant are shown in bold in Appendix 13 Table 13.1.

Thus the interpretation on the first variable is that those in their first pregnancy cost US\$4 more for outpatient care, and US\$45 more for overall CPP, compared to women not in their first pregnancy. Statistically significant variables are shown in bold in Table 9.4, and many of these are highly economically meaningful (>US\$12). Of particular note are previous stillbirth or neonatal loss (US\$170), previous reproductive tract surgery (US\$256), referral to a higher level (US\$441), hospital admission during pregnancy (US\$660), and pre-term infant (US\$973), and LBW baby (US\$1052). Why these risk factors or conditions were so costly cost can be examined by observing where the cost occurs. For example, most of the costs of pre-term or LBW infants were associated with neonatal care, and women referred to a higher level of care were more expensive in all categories, especially inpatient care during pregnancy. Note that for some variables, such as congenital malformation and adverse pregnancy event, some cost categories are significant, but overall cost is not significant. There were no events or risk factors that had a non-significant impact on costs (whether a single cost category or overall CPP).

8.3.1.2 2-way comparison results in Thailand

Appendix 13 Table 13.2 shows the 2-way results for Thailand. Again, most of the variables were statistically significant, especially elective CS (US\$119), adverse diagnosis at labour (US\$65) and previous surgery on reproductive tract (US\$96). The cost category with largest costs is postpartum care for the woman, which was largely related to the long length of stay following CS. The Table also shows that women with adverse outcomes of the labour or delivery period also have significantly higher ANC costs, such as post-term and induced labour. Risk factors or events that have a non-significant impact on costs included previous stillbirth, last baby LBW, and postpartum anaemia. The complete data set, broken down by arm and with 95% confidence intervals, is provided in Appendix 13 Table 13.5.

8.3.1.3 2-way comparison results in South Africa

Appendix 13 Table 13.3 shows that many of the variables are significantly different in South Africa, both statistically and economically. Women admitted for HDP in last pregnancy cost on average US\$157 more than women who were not; also referral

(US\$163), hospital admission in this pregnancy (US\$200), and adverse pregnancy event (US\$97) were highly significant. Also, adverse events during labour and delivery were responsible for higher costs, including adverse diagnosis at delivery (US\$107), preterm infant (US\$136), induced labour (US\$111), and elective CS (US\$413). Inpatient care both during pregnancy and after deliver were consistently the highest contributors to cost for most risk factors and events. Some events were significant for categories of cost, but not overall CPP, such as prelabour rupture of membranes and congenital malformation. The complete data set, broken down by arm and with 95% confidence intervals, is provided in Appendix 13 Table 13.6.

8.3.1.4 Cross-country comparisons and conclusions

The above analysis of comparing women/babies with risk factors or events against women/babies without these same risk factors or events has shown some significant findings, and some agreement as well as disagreement between countries. For example, there was agreement between countries that previous reproductive tract surgery, referred women, and women who had preterm infants increased costs. The significance of some factors has, however, merely confirm expectations, such as the cost impact of caesarean section or hospital admission. Cuba was the only country where previous stillbirth was significant, and Thailand was the only country where adverse pregnancy event was not significant. In Cuba, postpartum syhplis was not significant whereas it was in the other countries. Also, sizes of cost impact were different. For example, the cost increasing impact of a LBW baby and preterm infant were much greater in Cuba than in Thailand.

This analysis has also identified risk factors and events unlikely to influence cost, such as first or repeat pregnancy, previous baby LBW, congenital malformation (at overall CPP level), and postpartum anaemia. However, these variables are still included as independent variables in the regression analysis, in case their impacts are significant taking into account the multivariate effect. The next section tackles cost determinants in more depth using the technique of regression analysis.

8.4 Multiple regression analysis

8.4.1.1 MRA results in Cuba

The hand-built model gave an adjusted R^2 (R^{2^*}) of 0.85 in Cuba. This means that approximately 85% of the total variability in log ACPP was explained by the parameters listed in Table 8.7 below. Columns 2-5 show coefficients on variables found to be significant, with the mean value and lower and upper 95% confidence limits. Columns 6-9 show the percentage impact on base cost (the constant term) through back-transforming the log (base 10) value. The constant term is US\$1004, with a 95% confidence interval of US\$763 to US\$1324⁷⁵.

Table 8.4: Results of final regression model in Cuba

Variable	Coefficient			Change in cost (factor)			P value
	Lower	Mean	Upper	Lower	Mean	Upper	
Constant term	2.882	3.0021	3.122	763	1004	1324	9.82E-24
Pre-term labour	0.013	0.0267	0.040	1.031	1.06347	1.097	9.27E-05
Premature rupture of membranes	0.008	0.0178	0.027	1.019	1.04189	1.065	0.000289
Adverse diagnosis at labour	-0.018	-0.0099	-0.002	0.960	0.97754	0.995	0.013508
Birth weight (1 gramme change)	0.000	-0.0004	0.000	0.999	0.99912	0.999	9.82E-24
Birth weight squared	0.000	0.0000	0.000	1.000	1.00000	1.000	9.82E-24
Congenital malformation	-0.515	-0.3732	-0.231	0.305	0.42346	0.587	2.63E-07
Trial arm	0.016	0.028	0.040	1.0382	1.0674	1.0966	7.25E-14
Outpatient visits per full-time equivalent staff member	-0.001	-0.0007	-0.001	0.998	0.99829	0.999	2.27E-18
Occupancy rate	-0.004	-0.0033	-0.002	0.990	0.99250	0.995	1.43E-12
Monthly throughput of patients	0.000	0.0000	0.000	1.000	0.99998	1.000	4.65E-14
Hospital admission in pregnancy	0.336	0.3469	0.358	2.168	2.22265	2.279	9.82E-24
Mode of delivery (vaginal)	0.328	0.3364	0.345	2.128	2.16985	2.212	9.82E-24
Neonatal admission	0.628	0.6448	0.661	4.249	4.41323	4.584	9.82E-24

IPD – inpatient day

Examining the signs of the coefficients shows that the congenital malformation variable has a value of less than one, whereas the expected value is more than one. This result (of negative correlation) is supported by the findings of the univariate regression analysis, but contradicts the findings of the 2-way analysis where a net effect on CPP of congenital malformation is to increase it by US\$10. While the conflicting results may be due to interaction with other variables in the regression analysis, action was not considered essential due to the low incidence of congenital malformation. Before the

⁷⁵ However, this value corresponds to all independent variables taking a value of zero. For the average woman, values for birth weight, occupancy, and FTE per IPD take values of more than one, and therefore the constant term alone does not have any economic meaning on its' own.

coefficients are interpreted further, the strengths of the model are examined using various routine statistical tests. Table 8.8 shows how the regression model rated with respect to important model aspects (multicollinearity, cluster effect, normal distribution, heteroskedasticity, impact of outlying patients, comparison of model with step-wise).

Table 8.5: Diagnostic tools for regression models for Cuba, Thailand and South Africa.

Aspect of model	Details (& data source)	Cuba	Thailand	South Africa
Correct signs	Compare signs with expectations of economic theory	Congenital malformation -ive impact when +ive expected	All correct signs	Previous LBW: -ive impact when +ive expected
Multicollinearity (Pearson corr. coeff.)	(Appendix 14 Tables 14.1-14.3)	Some, but none >0.4	Some, but minor	Some, but minor
Cluster effect	Comparison of variance between clusters	Insignificant difference between clusters	Insignificant difference between clusters	Not relevant
Normal distribution	(Appendix 14 Figures 14.1-14.10)	Log transformation adequate	Log transformation adequate	Log transformation adequate
Heteroskedasticity	(Appendix 14 Figures 14.1-14.9)	Not a problem	Minor heteroskedasticity present	Minor heteroskedasticity present
Impact of outlying patients	Cook's distance	Four cases excluded	Two cases excluded	Zero cases excluded
Comparison of (hand-built) model with step-wise model	Differences in significant variables between two models	Step-wise had birth weight cubed	Step-wise had gestational age at first visit	Step-wise did not have previous LBW

Multicollinearity does not appear to be problem in Cuba. Appendix 14 Table 14.1 shows the Pearson correlation coefficients (between variables in Table 8.7 only). There appears to be some, though not serious, correlation between pre-term delivery and birth weight and between pre-term delivery and admission to the intensive care unit (<0.4). However, these rates are acceptable, and taking them out would lead to mis-specification, and therefore no adjustments were made to the model. The effect of the cluster design on the results was examined, by comparing the variability in cost per pregnancy between clusters, which was not found to be significantly different, using the F distribution.

Appendix 14 Figures 14.1 to 14.4 show that the skewness of the cost data was reduced considerably by applying a log transformation, so that OLS would be expected to give BLUE estimators. Appendix 15 Figure 15.1 shows that the regression residuals followed a normal distribution, and this is confirmed in Appendix 15 Figure 15.2 by a quartile-quartile plot. Appendix 15 Figure 15.3 indicates using a scatter plot of the regression standardised residual against the regression standardised predicted value that

heteroskedasticity is not a serious problem. This is because the variance in error term for larger cost values is not significantly (or consistently) greater than at lower cost values. In conclusion, no further transformations were considered necessary.

The impact of the leverage of outliers was examined using Cook's distance on all cases. The number of cases excluded due to the Cook's distance being >0.5 were four, thus not having significant impact on the results when these were excluded. The step-wise approach for Cuba, where inclusion/exclusion was controlled by the computer (inclusion criterion: $p < 0.05$) did not fit the regression better, with an R^2 of 0.85. The step-wise approach gave one more significant variable – birth weight cubed. The effects are relatively minor, and the F test for the difference between the two models was not significant at the 5% level. In conclusion, the step-wise and hand-built models give almost identical results. The results of the hand-built models are interpreted below.

As expected, the results in Table 8.7 show that the 'E' variables, actual health service use, were the most important predictors of cost, with a combined R^2 of 0.82, thus accounting for virtually all of explainable variation in cost per pregnancy. The coefficients on all these variables were large, ranging from an impact on cost of a factor of 2.17 for a CS instead of vaginal delivery to 4.4 for admission to intensive care unit. This corresponds to the expected cost impact⁷⁶. The cost impact if a woman is admitted to hospital during pregnancy is a factor of 2.2. If a woman had more than one of these, the impact on cost per pregnancy is multiplicative.

The other significant variables had less explanatory power than the health service use variables. In Cuba, there were no pre-pregnancy or pregnancy events that are significantly correlated with cost per pregnancy, from the regression, despite the significant results of the 2-way analysis in the previous section (e.g. previous reproductive tract surgery, previous spontaneous abortions, first pregnancies and postterm delivery). This is largely due to the effect of analysing variables together rather than separately. On the other hand, some indicators from the labour and delivery period were found to be predictive of cost per pregnancy. For example, pre-term labour

⁷⁶ For example, a neonatal admission would increase costs by an average (11 days ALOS \times US\$114 per day) = US\$1254. Compared to an ACPP of perhaps US\$300 without a neonatal admission, the factor impact of 4.4 is more or less correct.

increases costs by 6.3% and prelabour rupture of membranes by 4.2%, while adverse diagnosis at labour had a cost impact of -2.24%. Also, birth weight had an overall negative effect, as expected: as birth weight rises, ACPD reduces, although this would not apply outside the normal range of birth weight. Unfortunately, in the literature review there were no previous studies on maternal health events and outcomes against which to compare these results.

The characteristics of the polyclinic where women received outpatient care were also significant predictors of cost. For example, an increase in the number of outpatient visits per FTE by one unit decreased cost per pregnancy by 0.174%. Also, larger facilities had lower cost per pregnancy: roughly a 2% decrease for every 1,000 patient more per month. Facilities with higher occupancy rates had lower cost per pregnancy: a 1% increase in occupancy reduced cost by 0.75%. Although these effects were small - even for large differences between polyclinics - they were still significant, and confirms some results from the unit cost analysis in Chapter 8. Also, if the woman was in the intervention arm instead of the control arm, the cost impact was 6.6% (which is close to the observed average impact of 8% from the trial data set).

8.4.1.2 MRA results in Thailand

The hand-built model gave an R^2 of 0.505 in Thailand. This means that approximately 50% of the total variability in log ACPD was explained by the parameters listed in Table 8.9 below. The predicted cost when all parameters took a value of zero was US\$34.5, with a 95% confidence interval of US\$31.7 to US\$37.5. On examination for correct signs of the coefficients, all coefficients have the sign that would be expected. However, one variable - years at school - was ambiguous in its' impact on cost; the regression analysis found that more years at school had a significant increasing cost impact (1.6% for every additional year spent at school).

Appendix 14 Table 14.2 shows the bivariate correlations between variables in the final model, as measured by the Pearson correlation coefficient. There appears to be some, though not serious, correlation between which clinic the woman attended and the number of visits she had (as would be expected, due to intervention clinic consistently with less visits). As in Cuba, none of these variables were omitted in order to avoid mis-specification.

Table 8.6: Results of final regression model in Thailand

Variable	Coefficient			Change in cost (factor)			P value
	Lower	Mean	Upper	Lower	Mean	Upper	
Constant	1.502	1.538	1.574	31.735	34.506	37.519	8E-24
Years at school	0.005	0.007	0.009	1.012	1.0163	1.021	7.9E-13
Previous abortion	0.013	0.025	0.037	1.029	1.0589	1.089	7.2E-05
Previous surgery	0.066	0.112	0.157	1.165	1.2934	1.436	1.5E-06
Adverse diagnosis at labour	0.048	0.066	0.083	1.117	1.1634	1.211	2.3E-14
Induced labour	0.018	0.041	0.064	1.059	1.0990	1.480	0.0006
Postpartum syphilis	0.025	0.098	0.170	1.042	1.2519	1.160	0.0085
Trial arm	0.062	0.081	0.1001	1.153	1.2056	1.259	5.4E-12
Hospital identification	0.020	0.022	0.023	0.998	1.0514	0.999	8E-24
Inpatient days per full-time equivalent staff member	-0.001	-0.001	-0.001	1.048	0.9983	1.055	8E-24
Hospital admission in pregnancy	0.008	0.035	0.062	1.019	1.0840	1.154	0.0110
Mode of delivery (vaginal)	0.248	0.268	0.288	1.771	1.8533	1.939	8E-24
Neonatal admission	0.215	0.239	0.262	1.641	1.7328	1.830	8E-24

Appendix 15 Figure 15.4 shows using a histogram that the regression standardised residual does not follow a normal distribution, and has a long right hand tail. This shows up in the expected cumulative probability plot in Appendix 15 Figure 15.5, where the expected against observed cumulative probability plot is not close. The impact of this was not expected to change the results considerably, and the results are interpreted with this in mind. Appendix 15 Figure 15.6 indicates using a scatter plot of the regression standardised residual against the regression standardised predicted value that heteroskedasticity is not a serious problem. The impact of the leverage of outliers is examined using Cook's distance on all cases. The number of cases excluded due to the Cook's distance being >0.5 are two, thus not having significant impact on the results when these were excluded. The step-wise approach for Thailand fitted the regression slightly better, with adjusted R^2 of 0.52, and one two significant variables – gestational age at first visit (linear and cubed terms).

Table 9.9 shows that the 'E' variables, actual health service use, are the most important predictors of cost, with a combined adjusted R^2 of 0.382, thus accounting for a significant proportion of the explainable variation. The impact on cost of all these variables ranged from a factor of 1.084 for a hospital admission to 1.853 for a caesarean section.

Other parameters included in the model had less explanatory power. In Thailand, several risk factors, events at labour and delivery, and health provider characteristics were

significant. The risk factors influencing cost were the number of years at school, previous abortion and previous surgery on the reproductive tract, all of which had positive coefficients. The 2-way comparisons presented earlier showed that postpartum stay represented the major increase in cost due to these risk factors. Non-significant variables that were significant in the 2-way analysis included previous reproductive tract surgery, first pregnancies, premature rupture of membranes, and pre- and postterm delivery).

Three labour/delivery/postpartum events determined costs. Induced labour increased costs by 10%, adverse diagnosis at labour by 16% and postpartum syphilis by 25%. Most of the cost increases were in postpartum stay for the woman, but delivery costs were also increased. Some events that were expected to affect costs, such as birth weight, Apgar scores and fetal presentation at delivery, were found not to have a significant impact.

Only three hospital characteristics were significant determinants of cost. The results show that for an increase in one inpatient day per FTE, there was a decrease in cost of 0.17%. Inter-hospital differences were significant, with a move from the average hospital to the next costly hospital there was an increase in cost of 5%⁷⁷. Also, if the woman was in the intervention arm instead of the control arm, the cost impact was 20.5% (which is close to the observed average impact of 23.2% from the trial data set). Other measures of efficiency or cost determinants such as occupancy and size did not have significant impact on cost per pregnancy, although they were found to have some relationship in the unit cost analysis earlier. However, the unit cost analysis reported in Chapter 7 showed that efficiency indicators and size did not predict with confidence the unit cost of a hospital in Thailand, and it is assumed that was why they were not significant in the regression analysis.

8.4.1.3 MRA results in South Africa

The hand-built model gave an R^2 of 0.57 in South Africa. This means that approximately 57% of the total variability in log ACPP was explained by the parameters listed in Table 8.10 below. However, some variables were excluded due to the low

⁷⁷ This is used to calculate, for example, that the most expensive hospital is on average $6 \times 5\% = 30\%$ more expensive than the average hospital.

response rate, such as for gestational age at first visit, birth weight, and apgar score. Also, provider characteristics were not included, as women were not differentiated by which clinics or wards they attended. The predicted cost when all parameters take a value of zero was US\$158, with a 95% confidence interval of US\$140 to US\$177. On examination for correct signs of the coefficients, it appears that all coefficients were as expected, except ‘previous low birth weight’ which had a negative sign, when a positive sign was more likely.

Appendix 14 Table 14.3 shows the bivariate correlations between variables in the final model, as measured by the Pearson correlation coefficient. There appears to be some, though not serious, correlation between ‘adverse diagnosis at labour’ and neonatal admission, as well as malpresentation and CS, although no coefficients were over 0.3. Finally, CS and neonatal admission were correlated (0.34). However, none of these correlations were serious enough to exclude parameters from the model.

Table 8.7: Results of final regression model in South Africa

Variable	Coefficient			Change in cost (factor)			P value
	Lower	Mean	Upper	Lower	Mean	Upper	
Constant	2.148	2.198	2.248	140.6	157.76	177.03	4.32E-22
Previous low birth weight	-0.072	-0.035	0.002	0.847	0.92267	1.006	0.067366
Previous admission	0.029	0.121	0.213	1.068	1.32137	1.635	0.010461
First ANC visit < 20 weeks	-0.074	-0.041	-0.009	0.844	0.90906	0.979	0.012267
Referral to higher level care	0.005	0.040	0.076	1.011	1.09741	1.191	0.026401
Pre-term delivery	0.008	0.049	0.090	1.019	1.12003	1.231	0.019182
Prelabour rupture membranes	0.007	0.068	0.129	1.015	1.16823	1.344	0.030372
Malpresentation at delivery	0.006	0.036	0.066	1.014	1.08726	1.165	0.018471
Postpartum syphilis	0.024	0.088	0.152	1.058	1.22511	1.419	0.006913
Congenital malformation	0.027	0.173	0.318	1.065	1.48828	2.079	0.020083
Hospital admission in pregnancy	0.075	0.093	0.112	1.188	1.23981	1.294	2E-21
Mode of delivery (vaginal)	0.242	0.280	0.317	1.745	1.90373	2.077	4.32E-22
Neonatal admission	0.100	0.129	0.159	1.258	1.34620	1.440	5.19E-17

Appendix 15 Figure 15.7 shows using a histogram that the regression standardised residual followed roughly a normal distribution, which is confirmed in Appendix 15 Figure 15.8 where the expected against observed cumulative probability plot is acceptably close to the diagonal line. Appendix 15 Figure 15.9 indicates using a scatter plot of the regression standardised residual against the regression standardised predicted value that heteroskedasticity was not a serious problem, although there was a small funnel effect for the dense area of points shown by a darker shade. In conclusion, although some heteroskedasticity is likely to exist, it was not a serious enough problem

to require further transformation. The impact of the leverage of outliers was examined using Cook's distance on all cases. The number of cases excluded due to the Cook's distance being >0.5 was zero.

The results show that the 'E' variables, actual health service use, were the most important predictors of cost, with a combined adjusted R^2 of 0.536, thus accounting for most of the explainable variation. The impact on costs of all these variables was large, ranging from a factor of 1.24 for an admission to hospital to 1.904 for a caesarean section.

Other parameters had less explanatory power. In South Africa, risk factors, events at labour and delivery, and health provider characteristics affected cost per pregnancy. The risk factors that determined cost are previous admission (positive effect), previous low birth weight (negative effect), referral this pregnancy (positive effect) and gestational age at first visit (negative effect). This latter variable suggests that women that report later have a lower cost, probably because they receive less ANC visits. Four labour/delivery/postpartum events were found to determine costs. Pre-term delivery increases costs by 12%, PROM by 17%, malpresentation by 8.7%, postpartum syphilis by 22.5%, and congenital malformation by 49%. Non-significant variables that were significant in the 2-way analysis included admission for hypertension during a previous pregnancy, an adverse outcome during pregnancy, and induced labour.

8.4.1.4 Cross-country comparison of MRA results

The purpose of this section is to briefly identify similarities and differences between the results for Cuba, Thailand and South Africa, and make conclusions about the implications for cross-country prediction. Not only is there the issue of whether variables that are significant and non-significant are consistent between country, but also whether those parameters that have significant influence on cost per pregnancy have similar coefficient sizes.

First, R^{2^a} was considerably higher in Cuba than in Thailand and South Africa. Almost half of the variability in Thailand and South Africa could not be explained using parameters included in the model. The reason for this residual variation is likely to be because data were not collected on parameters that should have been included. There

may have been other patient or provider parameters influencing health service use or average cost, such as those identified and tested in Chapter 7. Some of these differences were identified using anecdotal data, such as the low postpartum stay in Si Chompoo hospital in Thailand due to a strict discharge policy. Also, variability in inpatient and delivery parameters was greater between health facilities in Thailand, because all women were assumed to receive inpatient and delivery care in the same hospital in Cuba and in South Africa. This may have accounted for a part of the difference in explained variation between Cuba and the other countries.

In terms of significant parameters, there were both important similarities and differences between countries. In all countries, for example, all health service use parameters were highly significant, and accounted for a large proportion of the explained variation. The coefficients were larger in Cuba for delivery and neonatal care, and this was probably due to the much higher cost and longer average length of stay for CS cases. Also, neonatal intensive care unit costs were high in Cuba.

The other significant parameters varied considerably between country. In Thailand and South Africa there were three risk factors having a statistically significant influence on cost, whereas in Cuba there were none, despite the significant results of the 2-way analysis. This suggests that low-risk women in Cuba did not receive considerably different amounts of care than women with risk, but also risk rates were much higher in Cuba due mainly to higher parity and a higher abortion rate.

On the other hand, women in Cuba and South Africa that had pre-term delivery or premature rupture of membranes had higher cost, whereas in Thailand the model predicts that these events do not affect cost significantly. Adverse diagnosis at labour was significant in Thailand and South Africa, but was negative and has limited impact on costs in Cuba. In Cuba, increasing birth weight had a small but negative effect on cost, probably because LBW babies were more likely to be admitted to the neonatal ICU. In Thailand, the low ICU admission and the relatively low cost of neonatal ICU means that it was not statistically significant.

Provider characteristics had a much greater effect on cost in Cuba. As already suggested, this was for the principal reason that unit cost was explained by efficiency indicators in Cuba better than in Thailand. However, due to the significant inter-provider variation in cost per pregnancy, the clinic identification variable was a highly significant parameter in both countries. Also, the clinic identification variable was a more important variable than whether it was in the control or intervention arm of the trial. This finding has serious implications for prediction of the costs of the new ANC programme, as additional information is needed on whether the provider tends to be a high, medium or low cost provider (due to the combined interaction of unit cost and health service use). This supports earlier conclusions of this chapter.

In conclusion, the MRA results have added an important additional perspective to the analysis of cost per pregnancy, and can potentially be used for cost prediction in the next chapter. Although the regression models for each country did not perform perfectly using the diagnostic instruments (some heteroskedasticity and multicollinearity), as well as some signs not as expected, OLS has explained cost per pregnancy relatively well.

8.5 Discussion and conclusion

This chapter has used several tools to explore determinants of cost per pregnancy, essentially to understand why cost per pregnancy varies between women who have different characteristics and who receive their care in different health facilities and countries. Also, the findings of previous analyses on the variability in health service use and unit costs was discussed further in the context of their impact on cost per pregnancy. Cost analysis found that cost per pregnancy varied significantly at the four levels at which it was examined: subgroup of women, the health provider, the trial arm, and the country. Variations at all levels have important implications for the generalisability of the costs of the W.H.O. ANC programme, both within and between countries. Findings are summarised and implications discussed below.

First, cost differences between arm in Cuba were not those expected from the reduction of 5.6 visits per woman, as more inpatient care was provided to intervention arm women. On the other hand, cost differences between arm in Thailand were roughly those expected from an average 3 reduction of three visits in the new ANC programme.

Also, the percentage reduction in cost in Thailand (19%) was much greater than in Cuba (7.5%). Therefore, careful thought needs to go into the prediction of costs for the new ANC programme in South Africa, depending on the impact on inpatient as well as outpatient care, rather than assuming a cost reduction.

Second, cost differences between health facilities were considerable, in fact making the cost differences between arm look less important. Table 8.1 clearly showed that the average reduction in CPP in each country hid some larger differences between individual health facilities within and between arm. This finding was confirmed in the regression analysis by the fact that both the trial arm variable and the health facility identification variable were both significant. Also, provider characteristics in the regression equation such as occupancy level, 'visits per FTE', and size were found to be especially significant in Cuba. In Thailand, 'days per FTE' was the only significant provider variable. The implications for cost prediction within country is that health facilities should be identified according to whether they tend to be high, medium or low cost, based on available data on health service use rates and unit cost levels.

Third, analysis of cost differences between women based on their defining characteristics gave some significant results, in both 2-way and multiple regression analysis. There were some similarities and differences between country in terms of which variables were significant, and the cost impact. Previous abortion, stillbirth, neonatal loss and surgery on reproductive tract in general were significant predictors of cost per pregnancy, while number of previous pregnancies, last baby LBW, previous pregnancy admission to hospital for HDP and the use of addictive substances did not have significant influence. Several events during pregnancy and delivery had a significant effect in all countries, including adverse diagnosis at labour, elective CS, and hospital admission during pregnancy, although the size of effect differed across country, being greater in Cuba and South Africa. Pre-term delivery and PROM were not significant in Thailand, but were significant in the other countries. Therefore, despite the cross-country similarities, it is unlikely that coefficients are generalisable between countries, due to different there being ACPP determinants, and different sizes of effect.

Fourth, cross-country differences in cost per pregnancy had several sources, including uncertainty, unit costs, and health service use. The greatest differences occurred where the high cost events (such as hospital admission, CS, or neonatal ICU admission) also had different rates between countries. This occurred particularly between Thailand and Cuba/South Africa. There was uncertainty in the most appropriate values for opportunity cost and exchange rates, thus reducing the confidence of conclusions regarding cost comparisons between countries. Also, the exclusion of private health care costs in Thailand and South Africa meant that CPP was underestimated.

In conclusion, this chapter has drawn together results from previous chapters, and placed them in the overall context of cost per pregnancy. This chapter also conducted further analyses to explore the causes of cost variation at the overall patient level. With the understanding and insights gained, the next chapter examines alternative cost prediction methods, to make final conclusions about the ability to predict the cost of pregnancy in developing countries.

9 COST PREDICTION

Following on from the last three chapters, where cross-setting cost variations were tested for significance and causes of variation examined, this chapter tests alternative cost prediction methods. The literature review identified a variety of techniques for predicting costs, based on different types of information and from different data sources. The five categories of cost prediction method tested are: direct cross-country transfer of costs; adjusted cross-country transfer of costs; cost predictions using assumptions about proportion of staff cost in average cost; incremental cost impact, based on detailed assessment of expected changes in health care provision, unit costs, morbidity rates and health service use; and cost prediction using coefficients from a regression model. In the first two sections, the incremental cost impact and the regression model methods are applied, and predictions presented. In the third section, the results of all the cost prediction results are presented, and comparisons made with observed costs to make conclusions about predictive accuracy. In the fourth section, the five cost prediction methods are critically evaluated. In particular, the performances of the cost prediction methods are compared with the expectations from earlier empirical results and from the literature review, and divergences explained. Also, their potential application and accuracy in lower income countries is explored. In the fifth section, the cost predictions in South Africa are interpreted, and conclusions made about which method(s) are likely to give the most accurate predictions there. The final section summarises and concludes.

9.1 Application of the incremental cost impact method

This section compares antenatal care practices as recommended in the W.H.O. antenatal care programme with current antenatal care practices in Cuba, Thailand and South Africa, and examines the likely impact on average costs and health service use of implementing the W.H.O. programme. Current and new ANC programmes were compared in terms of the number and timing of visits, content of visits, average impact on health outcomes, health service use, and costs.

9.1.1 Predicted changes to implement W.H.O. ANC programme

Number of antenatal visits

The expected number of antenatal visits in the intervention arm in Cuba is 6.06 visits per woman (range 4.72 to 7.1 visits)⁷⁸. In Thailand, the expected number is 4.23 visits per woman (range 4.11 to 4.55 visits)⁷⁹. In South Africa, the expected number is 4.3 visits per woman (range 3.6 to 5.0 visits)⁸⁰.

Content of antenatal visits

As well as the average number of antenatal visits, the contents of visits also affects the cost per pregnancy via the cost per visit. Therefore the hypothetical changes to medical practice required for each country to adopt the W.H.O. programme are examined, thus allowing assessment of likely changes in rates of morbidity, health service use, unit cost and finally cost per pregnancy. Appendix 16 Table 16.1 compares all aspects of the W.H.O. programme with current antenatal care in all three countries. Table 9.1 summarises the main differences between the W.H.O. programme and current practice, to allow assessment of potential impacts on costs and health status. The main difference

⁷⁸ The hypothetical effect of the new programme for low risk women in Cuba was a reduction in visits from an average of 13 per woman to 4, a reduction of 9 visits per woman. However, given the determinants of numbers of ANC visits discussed in Chapter 6, it is unlikely that a 4 visit average would be experienced in Cuba as 72% of women suffered some form of morbidity in Cuba (this includes any adverse pregnancy event, including mild sexually transmitted diseases) thus requiring further visits or inpatient stay. As the additional numbers of visits for these women cannot be predicted with the information available, assumptions were made that the average number of additional visits these women required was 3 (range 1 to 5). This figure is justified on the grounds that some women with adverse events would have up to 10 or 12 visits, while most would only have one or two extra, thus averaging around 3 extra each. This gives the average additional number of visits of 2.06 (= 3 visits per woman × 72% of women with a morbid condition requiring 3 extra visits) over the minimum of 4 visits extra visits per woman in all the trial population, with a range of 0.72 to 3.10 additional visits.

⁷⁹ The same calculation was done in Thailand as in Cuba, but with 7.5% of women having an adverse event during pregnancy leads to an average 0.23 additional visits per woman over the minimum of 4 visits (3 visits × 7.5% of women with a morbid condition requiring 3 extra visits) with a range of 0.11 to 0.55 additional visits.

⁸⁰ It is clear from the late reporting in South Africa that a large proportion of women under the W.H.O. programme would receive the health care interventions of visits 1 and 2 (and maybe visit 3) when they first attend ANC. Assuming these women are low risk and they comply with scheduled visits, these women would receive a maximum of 3 visits under the W.H.O. programme. This does not include women needing more visits, due to risk status or pregnancy events. Out of the 785 women in the sample, there were 550 medical events suffered by 377 women (urinary tract infection, trichomoniasis and syphilis accounted for 60% of these events). Assuming each event required an average of 2 visits additional visits each (range 1-3) this would lead to an extra 1.4 ($550/785 \times 2$) visits per woman (range 0.7 – 2.1 visits) from reporting after medical events [2 additional visits are assumed compared to 3 in Thailand and Cuba, because of later reporting in South Africa]. Added to the average number of visits of 2.9 visits per woman (from normal reporting), this would give 4.3 visits per woman (range 3.6 to 5.0). The figure of 2.9 visits per woman is arrived at by multiplying 4 visits by % women reporting under 20 weeks, 3 visits by % women reporting 20-32 weeks, and 2 visits by % women reporting >32 weeks.

in Cuba between the ANC programmes was expected to be the number of diagnostic tests required: multiple dipstick and rapid plasma reagent (syphilis test) to be added, and several tests to be reduced for low risk women, or taken out altogether. In Thailand, there were several interventions to add, including more history taking and risk scoring, as well as more records kept and a change to the appointment schedule. In South Africa, more background and history taking is required, as well as more formal risk scoring and laboratory tests, and time spent with the patient giving one-to-one advice and answering questions.

Table 9.1: Health care changes required from 'old' to 'new' antenatal care programmes.

ITEM	CUBA	THAILAND	SOUTH AFRICA
1. More interventions required	<ul style="list-style-type: none"> • More data on habits • Use handheld doppler • Multiple dipstick for UTI • On-the-spot RPR • More pap smear • Formal risk score • Emergency phone number • Keep home-based record 	<ul style="list-style-type: none"> • More data on background, habits, and other health care received by woman • Multiple dipstick for UTI • On-the-spot RPR • Pap smear • Formal risk score • Partner referral (syphilis) • Advise individually • Question and answer • Emergency phone number • Appointment system • Keep home-based record 	<ul style="list-style-type: none"> • More data on background, medical history, HIV status, habits, and other health care received • Pregnancy test in clinic • Take height on 1st visit • Multiple dipstick protein • On-the-spot RPR • Pap smear • ABO and rhesus test • Symphus-fundus on card • Formal risk score • Partner referral (syphilis) • Advise individually • Question and answer • Emergency phone number • Appointment system • Keep clinic-based record
2. Less interventions (not at all visits and/or only for high risk women)	<ul style="list-style-type: none"> • Less vaginal exams • Less protein in urine tests • Less haemoglobin tests • Less Hep B and HIV test • Less trichomoniasis test • Less ultrasound (HR) 	<ul style="list-style-type: none"> • Less protein in urine tests • Less haemoglobin tests 	<ul style="list-style-type: none"> • Less tetanus toxoid doses
3. Stop interventions (because not beneficial)	<ul style="list-style-type: none"> • Do not monitor weight • Do not do fasting glucose • Do not do haematocrit 	<ul style="list-style-type: none"> • Do not monitor weight • Do not do haematocrit 	<ul style="list-style-type: none"> • Do not monitor weight

Table key: UTI – urinary tract infection; RPR – rapid plasma reagent test for syphilis; HR – high risk

Unit cost per ANC visit

It was assumed that, as the main change in medical practice of the ANC programme was in outpatient ANC visits, these were the only unit costs that were likely to be affected. Any change predicted in the inpatient rate was assumed not to be sufficient to change occupancy levels, and therefore average costs of inpatient stay remained unchanged. Potential impact on outpatient ANC average cost was examined with respect to the use of staff, equipment, consumables, and change in monthly throughput of patients. Table

9.2 summarises the expected changes in resource use. The predicted impact on average cost in the countries were (see Table 9.2 for details):

- Cuba: a 10% increase in the base case (range no change to 20% increase) to US\$13.33 (range US\$12.12 to US\$14.54)
- Thailand: no impact was predicted in the base case (range 32% reduction to 32% increase) at US\$6.56 (range US\$4.46 to US\$8.66)
- South Africa: a 30.5% increase of US\$2.21 was predicted (range US\$1.13 increase to US\$3.53 increase) to US\$9.45 (range US\$8.37 to US\$10.78).

Inpatient admission

Following identification of the expected changes in the content and frequency of antenatal care, predictions were made about the likely impact of the W.H.O. programme on inpatient admission. In all countries, the main hypothesised effects of the W.H.O. recommended programme on women's health are through earlier diagnosis and treatment of syphilis⁸¹, and treatment of urinary tract infection (UTI). In fact, it was also likely that not only would women be treated earlier, but also rates might increase through improved diagnosis. For example, UTI 'no treatment' rates were expected to fall, and UTI 'with antibiotic treatment' expected to rise. Appendix 16 Table 16.2 shows the numbers and percentages of different adverse outcomes for women attending control arm clinics in study countries. In order to predict the increase in inpatient admissions due to higher detection rates, the rates of untreated UTI and hypertensive disorders of pregnancy (HDP) were taken from the control arm data set. However, there was considerable uncertainty associated with the actual change in diagnosis and admission rates, and therefore wide ranges are given on the base case prediction. In the base case scenario, the improved diagnosis and referral of women with UTI was assumed to lead to an increase in admission rate of 25% for women with untreated severe UTI (range 0% to 50%), with a length of stay of 7 days (the average for UTI cases). Also, the improved diagnosis and referral of women with HDP was assumed to lead to an increase in admission rate of 50% for women with untreated HDP (range 25% to 75%), with a length of stay of seven days (based on inpatient admission data for HDP). Few other

⁸¹ The numbers of diagnosed and treated sexually transmitted diseases were expected to rise due to immediate diagnosis and treatment, but these were assumed to have no impact on inpatient admission rates.

interventions in the W.H.O. programme were thought likely to impact major health outcomes listed in Appendix 16 Table 16.2.

Table 9.2: Average cost impact for outpatient ANC in study countries.

ITEM	CUBA	THAILAND	SOUTH AFRICA
Staff			
More staff time	Formal risk score, rapid syphilis test, vaginal examinations and home-based record in the clinics.	Additional personal data, formal risk score, rapid syphilis test, pap smear, and home-based record.	Additional personal data, formal risk score, rapid syphilis test, pap smear, one-to-one advice, and clinic-based record.
Less staff time	Less diagnostic tests from the laboratory.	Less diagnostic tests from the laboratory.	No third dose of tetanus toxoid administered.
Expected cost impact	10% increase in average cost per visit was assumed (range 0-20%) ¹ .	No impact ² .	No impact ² .
Equipment			
More equipment required	Rapid plasma reagent (for syphilis test) and a handheld doppler.	Rapid plasma reagent (for syphilis test).	Rapid plasma reagent (for syphilis test).
Expected cost impact	No impact ³ .	No impact ³ .	No impact ³ .
Materials			
Change in materials required	Less materials required due to less laboratory tests performed.	Less materials required due to less laboratory tests performed.	More materials required due to more laboratory tests performed.
Expected overall impact on material cost	No impact ⁴ .	No impact ⁴ .	Unit cost is increased by US\$0.40 (US\$7.25 × 1.055) ⁵ , range US\$0 to US\$0.80.
Throughput			
Change in throughput	The reduction in antenatal visits predicted were assumed to be replaced by other patients ⁶ .	Three assumptions: 1. Upper range: ANC receives 2 days a week ⁷ . 2. Base case: no effect on throughput. 3. Lower range: ANC receives 1 day a week.	ANC continues to be provided 2 days a week ⁸ .
Expected overall impact on unit cost	No impact.	The upper and lower ranges lead to a 32% increase and 32% decrease in average cost, respectively ⁹ .	The increase in average cost was predicted at US\$1.81 (US\$7.25×0.25) ¹⁰ . The range on this is US\$1.13 to US\$2.73 ¹¹ .

¹ An increase in unit cost was assumed because routine ANC required more time from obstetricians.

² Assuming the extra staff time required could be provided with the extra time available to staff due to less visits per day in the health promotion unit (Thailand) and health centre (South Africa), the impact on unit cost is assumed to occur due to changes in throughput, and not changes in total staff costs per se.

³ The investment in these equipment was assumed to have minimal impact on the cost per visit, given both the long life of equipment (depreciation) and the annual volume of patients using these equipment.

⁴ The expected saving in materials from less laboratory tests was difficult to identify, and was assumed to be minimal compared to unit costs.

⁵ Laboratory costs were assumed to increase by an average of 50% per visit (with a range of 'no impact' to 'doubling'). As laboratory contributes 11% of average cost, average cost was increased by 5.5%.

⁶ It was assumed that less ANC patients are replaced by other patients in the longer term, so that the net effect on throughput is zero.

⁷ Resulting in an average reduction of 42% of visits per day (visits reduced from 7.2 to 4.2).

⁸ Resulting in an average reduction of 27% of visits per day (visits reduced from 6 to 4.3).

⁹ Using data from the control group, where 77% of cost was fixed cost, this leads to a change in average cost of 32%.

¹⁰ Given that 94% of cost is fixed cost there would be an increase in average cost of 25%.

¹¹ US\$1.13 (with an average 5 visits per woman, leading to a reduction of 16.7% of visits) to US\$2.73 (with an average 3.6 visits per woman, leading to a reduction of 40% of visits).

9.1.2 Overall implications for cost per pregnancy

Table 9.3 shows the summary cost impacts for outpatient and inpatient care services (per woman and per visit, as specified), and predicted cost per pregnancy impacts. This table is built using the results of section 9.1.1. Table 9.3 shows that a saving of US\$81.2 was expected under the W.H.O. ANC programme in Cuba, with upper and lower values of US\$57.8 and US\$107 respectively. US\$81.2 was calculated by subtracting the predicted rise in inpatient cost of US\$1.8 from the predicted saving in outpatient care cost of US\$83).

Table 9.3: Summary of cost impact from W.H.O. ANC programme using incremental cost impact method

Variable	CI ¹	Cuba	Thailand	South Africa
Outpatient antenatal care				
1. ANC visits in control arm and predicted ANC visits in intervention arm	Low cost	13.0 & 7.1 visits	7.0 & 4.55 visits	5.8 & 3.6 visits
	Base case	13.1 & 6.06 visits	7.1 & 4.23 visits	6.0 & 4.3 visits
	High cost	13.2 & 4.72 visits	7.3 & 4.11 visits	6.2 & 5.0 visits
2. Outpatient ANC cost per visit change in intervention arm	Low cost	No change	32% decrease	15.4% increase
	Base case	10% increase	No change	30.5% increase
	High cost	20% increase	32% increase	48.7% increase
3. Outpatient ANC cost impact per woman in intervention arm	Low cost	US\$61 saving	US\$6.3 saving	US\$13.4 saving
	Base case	US\$83 saving	US\$16.7 saving	US\$2.9 saving
	High cost	US\$107 saving	US\$25.1 saving	US\$10.4 increase
Inpatient antenatal care				
4. Inpatient admissions (IPA) - total increase in intervention arm compared to control arm	Low cost	17.5 IPA	15.5 IPA	13 IPA
	Base case	154 IPA	63 IPA	31 IPA
	High cost	273 IPA	110 IPA	49 IPA
5. Inpatient cost increase per woman in intervention arm	Low cost	US\$3.2 increase	US\$0.2 increase	US\$3.54 increase
	Base case	US\$1.8 increase	US\$0.1 increase	US\$8.45 increase
	High cost	US\$0.2 increase	US\$0 increase	US\$13.35 increase
Cost per pregnancy				
6. Cost impact per woman with W.H.O. ANC programme (3. minus 5.)	Low cost	US\$57.8 saving	US\$6.1 saving	US\$9.86 saving
	Base case	US\$81.2 saving	US\$16.6 saving	US\$5.6 cost
	High cost	US\$107 saving	US\$25.1 saving	US\$23.8 cost

¹ Confidence interval: The low and high cost scenarios reflect the ranges predicted in the text above.

In Thailand, a saving of US\$16.6 was expected under the W.H.O. ANC programme, with upper and lower values of US\$6.1 and US\$25.1 respectively. In South Africa, a cost increase of US\$5.6 per woman was predicted under the W.H.O. ANC programme, with range US\$9.86 saving to US\$23.8 cost. This gives a predicted increase in cost per pregnancy from US\$347 to US\$352.6 (new programme cost range US\$337 to US\$371). Therefore, the inclusion of ranges in the analysis has shown that the new programme in South Africa may result in a cost saving as well as a cost increase.

9.2 Application of cost predictors from regression analysis

Cost predictions are made from regression analysis both within and between countries. In the first of three subsections, costs are predicted in each country by applying values for the average patients in each trial arm to the transformed coefficients (which give the cost impact of a unit change in the variable) *from the same country*. In the second subsection, costs are predicted in each country for ‘typical’ women by applying values for different profiles of women (such as high risk and low risk). In the third subsection, costs are predicted in each country by applying values for the average patients in each trial arm to the transformed coefficients *from the other countries*.

9.2.1 Cost prediction within country using ‘average’ trial patients

Table 9.4 shows which variables were included in the final regression models for each country (‘NS’ in the table indicates that the variable was either not significant and that there were no economic reasons apparent for retaining the variable in the final model). The values represent the cost impact associated with a unit change in the variables, with lower confidence limit, mean impact, and upper confidence limit. The interpretation of the coefficients, discussed in Chapter 8, is important for cost prediction. For example, if a woman has a pre-term delivery in Cuba, the cost per pregnancy increases by a factor of 1.063 from US\$1004.8 (the constant term) to US\$1068. If the same woman also has a CS, the percentages are multiplied ($1.063 \times 2.17 = 2.31$) giving US\$2321. If the average values for all parameters are applied to these cost impact factors, the cost for each trial arm is predicted. However, without all the values entered for those variables included in the final regression model, the constant term has limited meaning on its’ own. When average values for patients in the control arm in Cuba were applied to the coefficients, the mean predicted cost was US\$289 per pregnancy (lower and upper 95% confidence limits US\$78 and US\$1071). For the intervention arm, the predicted cost was US\$216 per pregnancy (US\$65 to US\$720). This gave a predicted incremental saving of US\$73 per pregnancy in Cuba (from the control to the intervention arms).

In Thailand, the predicted cost for the ‘average’ woman in the control arm was US\$98.9 per pregnancy (95% confidence limits US\$47 and US\$210). The predicted cost in the intervention arm was US\$69 per pregnancy (95% confidence limits US\$45 and US\$106). The predicted incremental cost was US\$30 per pregnancy.

Table 9.4: Independent variables explaining cost per pregnancy in study countries.

Parameter ¹	Unit change ²								
	Cuba			Thailand			South Africa		
	Low	Mean	High	Low	Mean	High	Low	Mean	High
Constant term	763	1005	1324	31.73	34.51	37.52	140.6	157.8	177.0
Previous history									
Years at school*	NS	NS	NS	1.012	1.016	1.021	NS	NS	NS
Abortion**	NS	NS	NS	1.029	1.059	1.089	NS	NS	NS
Surgery**	NS	NS	NS	1.165	1.293	1.436	NS	NS	NS
Pregnancy admission**	NS	NS	NS	NS	NS	NS	NS	NS	NS
Low birth weight**	NS	NS	NS	NS	NS	NS	0.847	0.923	1.006
This pregnancy									
First visit < 20 weeks**	NS	NS	NS	NS	NS	NS	0.844	0.909	0.979
Referral to higher level**	NS	NS	NS	NS	NS	NS	1.011	1.097	1.191
Pre-term labour**	1.031	1.063	1.097	NS	NS	NS	1.019	1.120	1.231
Premature rupture**	1.019	1.042	1.065	NS	NS	NS	1.015	1.168	1.344
Malpresentation at delivery**	NS	NS	NS	NS	NS	NS	1.014	1.087	1.165
Adverse diagnosis at labour**	0.960	0.978	0.995	1.117	1.163	1.211	NS	NS	NS
Induced labour**	NS	NS	NS	1.059	1.099	1.480	NS	NS	NS
Birth weight (1g change)* ³	0.999	0.999	0.999	NS	NS	NS	NS	NS	NS
Birth weight (1g) squared* ³	1.000	1.000	1.000	NS	NS	NS	NS	NS	NS
Congenital malformation**	0.305	0.423	0.587	NS	NS	NS	1.065	1.488	2.079
Postpartum syphilis**	NS	NS	NS	1.042	1.252	1.160	1.058	1.225	1.419
Trial arm**	1.038	1.067	1.097	1.153	1.205	1.259	NS	NS	NS
Hospital identification*	0.96	0.969	0.978	0.998	1.051	0.999	NS	NS	NS
Inpatient days per FTE*	0.998	0.998	0.999	1.048	0.998	1.055	NS	NS	NS
Occupancy rate (OPD)*	0.990	0.993	0.995	NS	NS	NS	NS	NS	NS
Monthly outpatients*	1.000	1.000	1.000	NS	NS	NS	NS	NS	NS
Hospital admission**	2.168	2.223	2.279	1.019	1.084	1.154	1.188	1.240	1.294
Delivery (vaginal)**	2.128	2.170	2.212	1.771	1.853	1.939	1.745	1.904	2.077
Neonatal admission**	4.249	4.413	4.584	1.641	1.733	1.830	1.258	1.346	1.440

NS – non-significant variable that was also not included in the final regression model for economic reasons; FTE – full-time equivalent staff member; OPD – outpatient department.

¹ * indicates a continuous variable; ** indicates a dummy variable. For continuous variables, the unit change value indicates the change that is predicted due to a one unit rise in the value of the variable.

² 'Low' = lower 95% confidence limit; 'High' = upper 95% confidence limit

³ The unit change is very close to, but not quite, 1.0 for these variables, because their values are high.

In South Africa, the predicted cost for the 'average' woman in the control arm was US\$271 per pregnancy (95% confidence limits US\$181 and US\$407). Values were then entered for a hypothetical intervention arm (values taken from the incremental cost impact method), with the same values for all parameters, except a rise in referrals from 23.2% to 28%, and inpatient admissions from 33.8% to 35.7%. This gave a predicted increase in cost per pregnancy of US\$4 to give an ACP of US\$275.

9.2.2 Cost prediction within country using profiles of women

Another exercise that tests the accuracy of cost predictions was to give different values to the parameters in Table 9.4, thus building a profile for types of women, and then predicting costs for women with these characteristics. Column 2 in Table 9.5 gives

information on four different profiles of women/neonates/provider, stating where the profile deviates from the base (in the base, dummy variables take a value of zero to reflect the low risk case, and continuous variables take the average value, unless otherwise stated). Table 9.5 shows that woman 2 is predicted to have the highest cost per pregnancy in all countries (see columns marked 'A'), at US\$1626 in Cuba, US\$406 in Thailand and US\$669 in South Africa. Ranges for each woman were also calculated, using the lower and upper values simultaneously for all significant coefficients, which reflected the lower and upper boundaries for women with those characteristics. However, these ranges are not provided as they were very wide (e.g. US\$485 to US\$5450 per pregnancy in Cuba for woman 2), and thus did not give a high degree of confidence to the predictions of average cost per pregnancy for women with these profiles.

Table 9.5: Cost predictions for women, neonates and providers with different profiles.

Woman	Characteristics ¹	Cuba (US\$) ²			Thailand (US\$) ²			South Africa (US\$) ²		
		A	B	A/B	A	B	A/B	A	B	A/B
1	Provider is inefficient, woman receives risk care and has hospital admission, neonate is admitted ³	1127	1787	63%	201	218	92%	378	460	82%
2	High number of ANC visits, woman receives referral ANC, has hospital admission and CS, neonate is low birth weight but not admitted ⁴	1626	965	165%	406	227	179%	669	613	109%
3	Low ANC visits, neonate has high birth weight, woman has syphilis ⁵	158	178	89%	79	99	80%	215	177	121%
4	Woman has admission and provider is efficient ⁶	978	564	172%	102	103	99%	344	410	84%

¹ The characteristics of women, providers and neonates are provided in this column that varied from the base profile (i.e. where dummy variables take a value of zero, and continuous variables take the average value)

² A: Predicted cost using regression model; B: Predicted cost using expected health service use of women and average costs; therefore A/B gives the percentage of predicted cost (using MRA) to 'expected' cost.

³ Woman 1 is predicted to have 13 ANC visits in Cuba, 7 ANC visits in Thailand, 6 ANC visits in South Africa; 7 ANC inpatient days, vaginal delivery, and neonatal admission.

⁴ Woman 2 is predicted to have 19 ANC visits in Cuba, 10 ANC visits in Thailand, 9 ANC visits in South Africa; 7 ANC inpatient days, caesarean delivery.

⁵ Woman 3 is predicted to have 9 ANC visits in Cuba, 4 ANC visits in Thailand, 3 ANC visits in South Africa; and vaginal delivery.

⁶ Woman 4 is predicted to have 13 ANC visits in Cuba, 7 ANC visits in Thailand, 6 ANC visits in South Africa; 7 ANC inpatient days and vaginal delivery.

These predictions were also compared with the cost per pregnancy expected from the health service use for women with each profile (health service use detailed in footnotes 3-6 in Table 9.5). The columns marked 'B' show the cost per pregnancy built up in this way. For example, the health service use of woman 2 in Cuba was predicted at

approximately 19 ANC visits, 7 inpatient days during pregnancy, CS, and 7 postpartum days, giving a cost per pregnancy of US\$965. The columns marked 'A/B' show the predicted cost per pregnancy from the regression model as a proportion of cost per pregnancy from building using expected health service use. The accuracy is discussed further in section 9.3.

9.2.3 Cost prediction between countries

Cost per pregnancy was predicted in each country by substituting parameter values into the regression equations of other countries (see Appendix 16 Table 16.3). For example, all the average parameter values for Thailand (each trial arm separately) and South Africa were applied in the Cuban cost prediction equation. This gave predicted cost per pregnancy in Thailand of US\$182 (intervention arm) and US\$192 (control arm), thus giving an incremental cost of US\$10. The predicted cost in South African (using the Cuban regression results) was US\$400 in the control arm.

Using the Thai regression results, cost per pregnancy in Cuba was predicted at US\$150 (intervention arm) and US\$156 (control arm), giving an incremental cost of US\$6, and in South Africa US\$148 in the control arm. Using the South African regression results, cost per pregnancy in Cuba was predicted at US\$268 in the control arm, and in Thailand US\$190 in the control arm. Section 9.3.5 also presents these results adjusted for differences in purchasing power between countries (see Appendix 16 Table 16.4).

9.3 Cost prediction results for all methods

Table 9.6 shows the summary results for the accuracy of all cost prediction methods at nominal exchange rates. Judgements about accuracy are made for both cost per pregnancy and incremental cost predictions in intervention and control arms, and are made according to: (1) predicted cost as a % of observed cost; (2) whether 95% confidence intervals of predicted and observed cost overlap (yes/no); (3) US\$ difference between predicted and observed cost; and (4) the difference in predicted and observed cost represented by the number of ANC visits. Appendix 16 Table 16.1 shows the full results at nominal exchange rates, and Appendix 16 Table 16.2 shows the same results, but at PPP values. The text also presents summary results on the accuracy of predicted marginal cost per pregnancy and median cost per pregnancy. The purpose of this section is to summarise how well each cost prediction method performs with respect to the

indicators of accuracy and economic significance. The discussion of why different methods were accurate or inaccurate, and whether they were in line with expectations given the conclusions of earlier chapters, follows in section 9.4.

Table 9.6: Summary results for all cost prediction methods, at nominal exchange rates.

Method	Source ¹	Arm ²	Cuba				Thailand				S Africa ⁷			
			% ³	Overlap ⁴	US\$ ⁵	ANC ⁶	% ³	Overlap ⁴	US\$ ⁵	ANC ⁶	% ³	Overlap ⁴	US\$ ⁵	ANC ⁶
Direct transfer	Cu	C	-	-	-	-	381%	n	296.4	45.2	116%	n	54.9	7.6
		I ⁸	-	-	-	-	434%	n	286.2	43.6	-	-	-	-
		C-I	-	-	-	-	151%	y	10.2	1.6	-	-	-	-
	Th	C	26%	n	-296.4	-24.5	-	-	-	-	30%	n	-241.5	-33.4
		I	23%	n	-286.2	-23.6	-	-	-	-	-	-	-	-
		C-I	66%	y	-10.2	-0.8	-	-	-	-	-	-	-	-
Adjusted transfer: Unit cost transfer	Cu	C	86%	n	-54.9	-4.5	335%	n	247.5	37.7	-	-	-	-
		I	-	-	-	-	166%	n	69.5	10.6	137%	y	130.0	18.0
		C-I	-	-	-	-	116%	y	3.1	0.5	-	-	-	-
	Th	C	41%	n	-235.9	-19.5	-	-	-	-	41%	n	-205.0	-28.3
		I	37%	n	-235.9	-19.5	-	-	-	-	-	-	-	-
		C-I	100%	y	0.0	0.0	-	-	-	-	-	-	-	-
Adjusted transfer: Health service use transfer	Cu	C	95%	y	-18.8	-1.6	196%	n	101.7	15.5	-	-	-	-
		I	-	-	-	-	157%	n	60.5	9.2	105%	y	19.0	2.6
		C-I	-	-	-	-	151%	n	50.3	7.7	-	-	-	-
	Th	C	44%	n	-226.9	-18.7	-	-	-	-	57%	n	-148.0	-20.4
		I	41%	n	-219.9	-18.1	-	-	-	-	-	-	-	-
		C-I	77%	y	-7.0	-0.6	-	-	-	-	-	-	-	-
Staff method	Sa	C	113%	y	51.6	4.3	124%	y	25.5	3.9	-	-	-	-
		I	76%	y	-97.9	-8.1	136%	y	38.5	5.9	102%	y	6.0	0.8
		C-I	77%	n	-84.9	-7.0	147%	y	40.3	6.1	-	-	-	-
Incremental cost impact method	C-I	C ⁸	57%	y	-13.0	-1.1	91%	y	-1.9	-0.3	-	-	-	-
		I	86%	n	-50.9	-4.2	104%	y	3.7	0.6	-	-	-	-
		C-I	269%	y	50.9	4.2	81%	y	-3.8	-0.3	-	-	-	-
Regression model	Own ⁹	C	72%	y	-112.6	-9.3	94%	y	-6.5	-1.0	78%	y	-76.0	-10.5
		I	58%	y	-155.9	-12.9	81%	y	-16.7	-2.5	-	-	-	-
		C-I	220%	y	36.0	3.0	151%	n	10.1	1.5	-	-	-	-
	Cu	C	-	-	-	-	182%	y	86.2	13.1	115%	y	52.9	7.3
		I	-	-	-	-	212%	y	96.3	14.7	-	-	-	-
		C-I	-	-	-	-	49%	y	-10.2	-1.5	-	-	-	-
	Th	C	39%	n	-246.0	-20.3	-	-	-	-	43%	n	-199.0	-27.5
		I	40%	n	-221.9	-18.3	-	-	-	-	-	-	-	-
		C-I	20%	y	-24.1	-2.0	-	-	-	-	-	-	-	-
	Sa	C	67%	n	-133.7	-11.0	183%	n	87.1	13.3	-	-	-	-

¹ The data source for the prediction: Cu – Cuba; Th – Thailand; Sa – South Africa.
² The trial arm for which cost is predicted (I – intervention arm; C – control arm; or 'C - I' equals the difference)
³ % indicates (predicted cost + observed cost) × 100 .
⁴ Overlap: 'y' indicates that the confidence intervals for predicted cost and observed cost overlap. 'n' means no overlap.
⁵ US\$ indicates the money amount by which predicted cost exceeds observed cost, at the nominal exchange rate. If the number is negative, it means that observed cost > predicted cost.
⁶ ANC indicates the value by which predicted cost exceeds observed cost represented by number of ANC visits. If the number is negative, it means that observed cost > predicted cost.
⁷ For South Africa, there are no intervention arm observed costs, and therefore judgements about accuracy in the intervention arm cannot be made.
⁸ There is no predicted cost in the control arm for the incremental cost impact method.
⁹ 'Own' means that the average parameter values in both trial arms in study countries are used to predict costs in the same country.

9.3.1 Direct transfer method

Table 9.6 shows that the direct transfer method was 'inaccurate'⁸² when transferring average cost per pregnancy (ACPP) between Thailand and the other two countries at nominal exchange rates. For example, when transferring ACPP from Thailand to Cuba, predictions were 23% to 26% of observed ACPP in Cuba, and were inaccurate by over US\$250. On the other hand, transfer of incremental cost from Thailand to Cuba was accurate; also, the inaccuracy of US\$10 in incremental cost was not 'economically' significant⁸³. Direct transfer of ACPP between Cuba and South Africa proved to be closer to observed ACPP, due to the similarity in costs between countries at nominal exchange rates. For example, South African ACPP transferred to Cuba was 86% of observed ACPP in Cuba, but the US\$55 difference with observed ACPP was economically significant, and confidence intervals did not overlap. In summary, at nominal exchange rates direct transfer of ACPP was not consistently accurate between country, whereas direct transfer of incremental costs was accurate in all transfers.

Cost predictions were also made and compared using alternative assumptions. First, the cost predictions were compared using the confidence intervals for observed cost that were obtained from the sensitivity analysis (see Chapters 7 and 8). While the confidence intervals for Thailand and the other countries became closer using the ranges from sensitivity analysis (see Table 8.3), the changes were not large enough to make cost predictions under uncertainty accurate between Thailand and other countries. Second, costs were predicted using purchasing power parities (PPP) instead of nominal exchange rates. Appendix 16 Table 16.2 shows the full cost prediction results using PPP, and the levels of accuracy obtained. The results show that cost predictions using PPP were less accurate for predictions involving Cuba than under nominal exchange rates. This was because the adjustment factor for converting nominal exchange rates to purchasing power parities was larger in Cuba (2.38) compared to Thailand (1.94) and South Africa (1.55). The implications of Cuban costs having the greatest upward adjustment means that money transfers between Cuba and the other two countries were less accurate than previously at nominal exchange rates. Therefore, some of the direct transfers between

⁸² As described in Chapter 5, an 'accurate' prediction occurs when the 95% confidence intervals (or range if confidence intervals not available) of predicted and observed costs overlap.

⁸³ As described in Chapter 5, if the difference between predicted and observed cost is more than the cost of one antenatal care visit (in each country), then it is judged to be economically meaningful.

Cuba and South Africa that were previously accurate became inaccurate using PPP. On the other hand, there was a small convergence between costs in South Africa and Thailand, because the lower cost country (Thailand) had a larger adjustment factor. However, as cost transfers between these two countries were highly inaccurate previously, the change was not large enough for cost predictions between Thailand and South Africa to become accurate.

Third, costs were predicted using black market exchange rates for non-traded goods in Cuba, and May 1999 instead of January 1998 nominal exchange rates for the other countries. Under these assumptions considerable convergence was found, with ACPP in Cuba reducing to US\$144 (range US\$137-US\$151) in the control arm compared to US\$275 (US\$257-US\$294) in South Africa and US\$150 (US\$146-US\$154) in Thailand. Therefore ACPP prediction under alternative exchange rates lead to similar costs in Cuba and Thailand, and therefore the direct transfer method as accurate, and economically insignificant. However, the convergence seen between Thailand and South Africa at alternative exchange rates was not sufficient to be considered accurate. On the other hand, when the ACPP ranges from the sensitivity analysis were used, predictions were accurate (95% confidence interval in Thailand US\$116-US\$247 and in South Africa US\$206-US\$470). Therefore, the exchange rate chosen and the degree of uncertainty present both heavily influence whether or not cost predictions using direct transfer are accurate or not.

Fourth, marginal cost per pregnancy (MCP) was predicted. Under nominal exchange rates, MCP in Cuba was substantially higher than the other countries, and direct transfer did not give accurate ACPP predictions (Table 8.1 provides the data). For example, in the control arms MCP was US\$116 in Cuba (95% confidence interval US\$110-US\$121), compared with US\$41 in South Africa (US\$37-US\$45) and US\$22.6 in Thailand (US\$22-US\$23). When purchasing power parities were used, costs in Cuba became even higher, and also costs did not converge sufficiently between Thailand and South Africa for cost predictions to become accurate (Table 8.2 provides the data). However, when May 1999 nominal exchange rates were used (instead of January 1998), cost per pregnancy converged sufficiently for cost transfers to be accurate (Table 8.3 provides the data). Finally, when cross-country differences in uncertainty were taken

into account, marginal cost per pregnancy ranges overlapped between Thailand and South Africa (Table 8.3 provides the data).

Fifth, median costs were also predicted across country using the direct transfer method. Confidence intervals were not presented for median costs and therefore conclusions were not made about accuracy of direct transfer of median costs. In predicting point estimates from one country to another, the differences between predicted and observed median costs were economically significant. For example, in the control arms, observed median costs were highest in Cuba (US\$240), followed by South Africa (US\$214) and Thailand (US\$80).

Sixth, using the same approach as in the regression analysis, ACPP predictions were built by identifying the likely health service use of different profiles of women. The accuracy of cost per pregnancy predictions were compared between the highest cost woman (number 2 in Table 9.5) and the lowest cost woman (number 2 in Table 9.5), to see whether there are differences in accuracy of different profiles of women. The low cost woman was predicted to cost US\$178 in Cuba, US\$177 in South Africa, and US\$99 in Thailand. Therefore, cost transfer between Cuba and South Africa would be accurate (with only US\$1 difference) and between these countries and Thailand would be inaccurate (Thailand ACPP is under 56% of ACPP in the other countries). The high cost woman was predicted to cost US\$980 in Cuba, US\$613 in South Africa, and US\$227 in Thailand. Therefore, cost transfer between Cuba and South Africa would be less accurate (South Africa ACPP 62% of Cuba) and between these countries and Thailand would be inaccurate (Thailand ACPP is under 40% of ACPP in South Africa and under 25% in Cuba). In conclusion, direct transfers are more accurate using low cost women in terms of % difference between predicted and observed costs.

9.3.2 Adjusted transfer method

The results of two types of adjustment to predict ACPP are presented in Table 9.6. First, unit costs were transferred between countries, using local health service use data. Compared to the direct transfer method, cost predictions in Cuba and Thailand became considerably more accurate, with differences reducing from US\$296 under direct transfer to US\$69 under adjusted transfer. However, changes were not large enough for ACPP predictions to become accurate or economically insignificant, although

incremental cost was accurate (US\$23 predicted versus US\$20 observed), with the difference not economically different. On the other hand, transfer of unit costs from Cuba to South Africa lead to less accurate ACPD predictions than the direct transfer method, with inaccuracy increasing from US\$55 to US\$130 in the control arms. At PPP, as under the direct transfer method, ACPD transfers involving Cuba became less accurate, whereas between Thailand and South Africa accuracy improved (but not enough for confidence intervals to overlap).

Second, health service use was transferred between countries, with local unit costs data. When using local prices in Thailand and transferred health service use from Cuba and South Africa, the predictions of cost per pregnancy increased in accuracy. Accurate predictions occurred using the control arm data from South Africa in Thailand, giving US\$131 (range US\$103 to US\$159) and overlapping confidence intervals. Using transferred health service use data from the control arm in Cuba to predict cost per pregnancy in South Africa gave an accurate cost prediction: at US\$366 it was only US\$19 from observed cost (economically meaningful). Finally, using South African health service use data to predict ACPD in the control arm in Cuba gave an accurate ACPD prediction.

9.3.3 Simplified staff cost prediction method

Predicting unit costs using the simplified staff method, and using local health service use data to predict cost per pregnancy, gave overlapping confidence intervals⁸⁴ for all ACPD predictions in Thailand and South Africa. In South Africa predicted ACPD was US\$24 less than observed costs in the control arm. In Thailand, predicted costs were US\$38-US\$40 more than observed costs (confidence intervals overlapping, but economically significant difference); however, predicted incremental costs were within US\$2 of observed incremental costs. In Cuba the simplified staff cost prediction method under-predicted costs by as much as US\$100 (and thus there was no overlap with observed costs), although incremental costs were accurate at US\$13 different (on the border of economic significance).

⁸⁴ Using this method, ranges were calculated using ranges on input values for % staff and % direct cost in average costs (Appendix 16 Tables 5 and 6 give these ranges).

9.3.4 Incremental cost impact method

The incremental cost impact method gave a predicted cost per pregnancy in the intervention arm in Cuba at US\$321 (range US\$295 to US\$344) and in Thailand at US\$89 (range US\$81 to US\$100). Therefore, predictions were accurate for both countries (when compared with observed costs, see Appendix 16 Table 16.3). Predicted ACP was 87% and 103% of observed cost in Cuba and Thailand, respectively, giving accurate predicted incremental costs of US\$81 in Cuba (range US\$58 to US\$107) and US\$16.6 in Thailand (range US\$6 to US\$25). Although accurate, all recorded differences in predicted and observed costs using ICIM were economically significant. Predicted incremental cost was over four ANC visits inaccurate in Cuba (US\$51). In South Africa, as already presented in section 9.1 the ICIM predicted cost pre pregnancy to increase by US\$5.65 to US\$353. However, the predicted incremental cost range covered zero, from a saving of US\$10 per pregnancy to an additional cost of US\$24 per pregnancy under the W.H.O. ANC programme.

9.3.5 Regression analysis cost predictors

Using coefficients from the final regression model to predict costs within the original country, and applying values for the average patients in each trial arm, gave predicted costs less than observed costs in all trial arms and for all countries. In Cuba, the predicted cost was US\$156 and US\$113 less than observed cost in the intervention and control arms respectively (58% and 72% of observed cost). The predicted incremental cost of US\$73 was outside the base case incremental cost confidence interval of -US\$2 to US\$63, and the difference with observed incremental cost of US\$43 (US\$73 minus US\$30) was economically significant. In Thailand, predicted cost was 80-83% of observed cost, with a difference of between US\$7 and US\$17. The predicted incremental cost of US\$16.6 was very close to the base case incremental cost confidence interval of US\$20 (range US\$16 to US\$24), and therefore the difference of US\$3.40 was not economically meaningful. In South Africa, predicted cost was US\$271 (a difference of US\$82 with observed ACP), which was 76% of observed cost, and an economically meaningful difference. Predicted cost was closer to observed cost in the control arm compared to the intervention arm in both Cuba and Thailand.

Applying values for profiles of patient gave mixed results, as shown in Table 9.5. In all countries there were both over- and under-predictions. Two women were consistently

under- and over-predicted: woman 1 was under-predicted in all countries (63-92% of the cost expected from the likely health service use of the woman), while woman 2 was over-predicted in all countries (109-165% of the cost expected from the likely health service use of the woman). The smallest range of inaccuracy occurred in South Africa (predicted cost 84% to 121% of observed cost) and the largest Cuba (predicted cost 63% to 172% of observed cost). Only for woman 4 in Thailand was the prediction very close to observed cost (US\$1 different); the next closest prediction was US\$17 different for woman 1 in Thailand and then US\$56 different for woman 2 in South Africa.

Using the Cuban regression results to predict costs in the other countries lead to an over-prediction, from 115% of observed cost in South Africa to 181% observed costs in Thailand in the control arms, to 212% observed costs in Thailand in the intervention arm. The Thai regression results under-predicted costs in the other countries, where predicted cost was around 40-50% of observed cost in both Cuba and South Africa. Finally, the South African regression results under-predicted costs in Cuba by US\$113-133 (67-76% of observed cost) and over-predicted costs in Thailand by US\$87-96 (183-222% observed cost). While most predictions were accurate (on account of the very wide confidence intervals from the regression equation), all differences were economically meaningful. The predicted incremental cost in all cross-country predictions were not more than US\$10-21 different from the observed incremental cost, and these differences were worth between 1.6 and 3.0 antenatal visits in all countries, and therefore economically significant.

Finally, cross-country predictions were adjusted by differences between country in purchasing power, to take into account different prices in the three countries. Two measures of purchasing power were used: (1) the PPP values used earlier, and (2) average staff salary levels. Out of these two measures, the use of PPP resulted in greater accuracy between Cuba and the other countries. For example, cost predicted in Cuba from the Thai regression equation improved from US\$156 to US\$190 in the intervention arm; and from the South African regression equation from US\$268 to US\$410, compared with US\$402 observed cost in the control arm in Cuba. In the latter case, the cost prediction was almost exact. Using the average staff salary levels as adjustment factor in cross-country predictions, costs predictions in all countries became

less accurate than they were in the original predictions. For example, costs predicted in Cuba from South Africa were adjusted down to US\$51, on account of the very high salary levels in South Africa.

9.4 Critical evaluation of cost prediction methods and results

This section evaluates each of the cost prediction methods in turn, in terms of: which cost(s) can be predicted, whether expectations of performance were in line with actual performance, and what factors affected performance. If methods did not meet expectations, reasons are examined why not. Cost prediction methods are also critiqued in terms of what the method can and cannot do (for example, how they deal with distributions of cost). Finally, the methods are assessed in terms of how they might perform in other settings, in particular in lower income settings.

9.4.1 Direct transfer method

Any cost component (see Box 1.1) can be predicted using the direct transfer method, although only cost per pregnancy was predicted in this thesis. Chapters 6 and 7 provided a detailed examination of how much countries varied in components of cost per pregnancy (with confidence intervals provided), and by implication that direct transfers would be inaccurate. How the method was expected to perform was based on how similar cost magnitudes are across countries, such as might be suggested by health care expenditure of gross national product (GNP) per capita, or price levels of key resources. At nominal exchange rates, 1997 GNP per capita was marginally higher in South Africa (US\$3160) than Thailand (US\$2740), and both were higher than Cuba (US\$1021) (World Bank 1997). Therefore, under the naïve assumption that health care costs and GNP per capita are linearly related, Cuba was expected to have the lowest cost per pregnancy at nominal exchange rates. At PPP, the ranking between countries changed, with GNP per capita US\$7540 in Thailand greater than South Africa (US\$5030) and Cuba (US\$2430)⁸⁵. However, given that Cuba is well known for having a high level of health care expenditure per capita, the expectation was that GNP per capita would not be a good indicator of cost per pregnancy.

The results did indeed show that GDP per capita is not a good predictor of cost per pregnancy. In fact, the predictive accuracy of cost per pregnancy (both mean and

median) between Cuba and South Africa was much higher than with Thailand. Using MCPP resulted in less accurate predictions, as the proportion of variable cost to fixed cost was higher in Cuba.

In terms of expected incremental costs, the expected change in all countries was a zero change or cost saving under the W.H.O. programme, due to the reduction in average ANC visits per woman and negligible expected impact on inpatient services. The direct transfer in incremental costs between countries resulted in accurate predictions for most transfers. This was not greatly surprising, given that similar changes were expected in all countries (i.e. in no country was there required increases in the levels of services). However, it is clear that these predictions were only accurate because in all countries the cost changes were minimal (countries faced similar levels of change) and that the same accuracy would not be experienced occur where larger changes are needed. Therefore, when applying this method in lower income countries, it is likely to be inaccurate.

Also, the results showed clearly that accuracy depended to a large degree on which currency conversion method was used. While costs were transferred accurately between Cuba and South Africa at nominal exchange rates, they were not transferred accurately using PPP for all countries or black market rates for Cuba. The result that the use of PPPs did not make costs between countries converge has implications for the use of PPPs in generalising cost data across countries – that cost magnitude is not necessarily a direct function of local prices, due to the influence of the quantity elements and in unit costs (resource use) and cost per pregnancy (health service use).

The main disadvantage of the direct transfer method is that it does not take into account different absolute and relative prices or unit costs, and therefore input and service intensity and mix. In transferring unit costs between country, inefficiency that may not exist in the target country is also transferred. However, cross-country differences in efficiency were not calculated, although proxied by visits or days per full-time equivalent staff member, where South Africa was shown to be the most efficient country for outpatient services. Also, in transferring health service use between countries, the way local practice style and rationing measures interact with unit costs are not allowed

⁸⁵ Using PPP values used in this thesis.

for. For example, if caesarean sections were to cost more, they may be rationed more severely.

Another disadvantage of the direct transfer method is that it does not take into account differences in cost per pregnancy distributions between countries, or the causes of these distributions. For example, in both Cuba and Thailand there were bimodal distributions (refer to Appendix 14 Tables 14.3, 14.4, 14.7, 14.8) whereas in South Africa there was a single mode and a long right-hand tail (Appendix 14 Table 14.10). In Cuba, the smaller second mode was caused by women having a CS or babies who are admitted. In Thailand, the second mode was caused by women admitted to a secondary hospital (where the average costs were substantially higher than at the district hospitals). In Cuba the second mode occurred at US\$450-600, while in Thailand it was at US\$170-230. Therefore, direct transfer does not predict mean costs, median costs or special characteristics of cost distributions, unless similarities exist between countries.

Finally, in support of the direct transfer method it is a quick method and it has minimal data requirements, and therefore can be used for back-of-the-envelope calculations before adjustments are made. However, if data are disaggregated and cost determinants are known, then the adjusted transfer method is recommended.

9.4.2 Adjusted transfer method

By definition, the adjusted transfer method requires some data to be transferred and mixed with some local data, to predict cost per pregnancy. In this thesis, unit costs and health service use were transferred. It therefore gives an opportunity to improve on the accuracy of the direct transfer method, but only where data are sufficiently disaggregated and cost determinants are understood. In general the adjusted transfer method improved on the direct transfer method. For example, predicting ACPP in the control arm in Thailand using Cuban unit costs lead to a US\$175 ACPP prediction in the intervention arm compared to US\$402 using the direct transfer method, which is closer to the observed US\$106 ACPP. However, using Cuban unit costs to predict ACPP in South Africa lead to less accuracy than the direct transfer method. This was because very high neonatal care average costs in Cuba were applied to a very high days per neonate rate in South Africa, thus leading to a higher ACPP in South Africa than that observed.

A disadvantage of this method is that, while it does separate the two main components of cost per pregnancy, it does not allow for interactions between average cost and health service use that occur. This point can be illustrated by the Cuba/South Africa case just mentioned, where the transfer of a higher neonatal day average cost as experienced in Cuba (US\$114) is likely to cause lower health service use rate from the average 1.69 days per neonate.

The adjusted transfer method potentially reflects the local distribution in cost per pregnancy. However, this only occurs if the local data used (e.g. health service use) is the main determinant of the shape of the distribution, and that the transferred data does not change the distribution. For example, if the presence of a CS in Cuba causes a bimodal distribution due to the associated length of postpartum stay (and not the high cost of a CS itself), then it could be concluded that the second mode is caused mainly by high health service use and not by high unit costs. Thus the bimodal distribution is successfully predicted in Cuba when unit costs are transferred from Thailand or South Africa. Conversely, the bimodal distribution is not successfully predicted when health service use is transferred from a country with a short postpartum length of stay and/or low CS rate. Therefore, the successful prediction of distribution depends on which cost component is transferred, and whether the transferred data varies substantially from the observed values in the country of the cost prediction.

Finally, an aspect of the adjusted transfer method to note is that if adjustments are made without any analysis of cost determinants, one does not know much accuracy is increased. Cost differences between country may be driven by one or two components, such as the price or use of a particular service. For example, both the unit cost of neonatal care in Cuba and the number of days per neonate in South Africa are major forces driving cost differences with Thailand. Therefore these cost drivers must be identified before adjustments are attempted. This is a particularly important point to bear in mind if the adjusted transfer method is used to predict costs in lower resourced settings.

9.4.3 Simplified staff cost method

The simplified staff cost method essentially predicts average costs (per health service) based on assumptions about the values of key variables. These values can either be based on locally collected data, as was done in this study, or using transferred data⁸⁶. Average costs can then be combined with either local or transferred health service use data to predict cost per pregnancy. In this study, predicted average costs were combined with local health service use data, to pinpoint the inaccuracy in cost per pregnancy caused by inaccuracy in average costs. As this method was not found in the literature review, there are no expectations from previous findings. Accuracy depends on which data are used to reflect % of staff cost and % direct cost in average costs, whether the average salaries reflect the average staff, and whether full-time equivalent staff and throughput are measured accurately. Using data from the costing study, these data were considered to be good quality and therefore the expectation was that average costs would be predicted reasonably well. In both Thailand and South Africa, ACPP and incremental costs were predicted accurately; in Cuba, incremental cost only was predicted accurately.

While these results could lead one to conclude that this method was a success, inter-health facility variability was examined to identify whether aggregate predictions masked greater variability elsewhere. Appendix 17 Tables 17.3 and 17.4 show variation between health facilities within Cuba and Thailand. In Cuba, predicted cost as a % of observed cost ranged from 43% to 98% (outpatient clinics) and 68% to 95% (inpatient wards), giving an overall under-prediction of about 24%. In Thailand, these figures ranged from 55% to 162% (outpatient clinics) and from 97% to 500% (inpatient care). Delivery care in Thailand had even greater variability (57% to 667%) with an average of 143%. However, due to over-prediction in some clinics and under-prediction in others, the net result appeared much more accurate in Thailand. The implication of this result is that if average costs were predicted in any single clinic, there is considerable uncertainty over whether it under- or over-predicts, and therefore there is a much wider confidence interval than would occur under a large sample of health facilities. Therefore, this method is not recommended for single centre cost studies where predictions cannot be validated.

The next issue concerns what factors actually cause variability and inaccuracy. First, some variability was observed within and between countries in the % contribution of staff and direct costs to average cost. (see Appendix 9 Tables 9.4 to 9.9). However, there were few patterns found between countries and different types of care in % contribution of staff and direct costs to average cost. For example, % staff contribution to an outpatient visit ranged from 56% in Cuba to 88% in South Africa. Also, staff may not always be the main resource ingredient, such as in Thailand where the % contribution for vaginal deliveries was as low as 29%. Therefore, there is considerable uncertainty in using this method in a country where this data is not available, as it would require making assumptions about cost contributors. Also, average (mid-scale) salary levels for a country may not apply to all the facilities within that country, as lower or higher grades of staff may be employed in some facilities. Therefore, there is considerable potential for inaccuracy, as was found when individual health facilities were compared.

9.4.4 Incremental cost impact method

All components of cost can be predicted using the incremental cost impact method – i.e. unit costs, health service use, and cost per pregnancy. However, this method relies on baseline data on unit costs, health service, health service use, and patient characteristics. The expectations were that the predictive accuracy would be high, and at least improve on the adjusted transfer method, due to the setting-specific nature of the method, and the detail of the data available for this study.

Section 9.3 presented the results, showing that the ACPP predictions were accurate, although the US\$ differences compared to observed ACPP and incremental cost were more than expected for Cuba. In Cuba, the observed effect of the intervention arm was to increase costs for inpatient care more than expected, and the predicted reduction of seven visits was not quite achieved (6 instead). Table 6.2 shows the differences between trial arms for inpatient services. Chapter 6 concluded that these differences could not be explained by the change in the ANC intervention alone, and that some of the effect was likely to be due to random variation. Therefore, this raises questions about whether the

⁸⁶ Local data was used in order to maximise the chance of getting accurate predictions, to see whether this method works, and if not, why not.

same costs would be observed if the trial were run again, therefore with implications for the accuracy of the incremental cost impact method.

Another feature of ICIM was that ACPP predictions are made for the aggregate level, but variability is not expressed in terms of probability distributions, but only ranges where the upper and lower likelihood for the whole population ACPP is predicted. Also, the results are open to manipulation, due to the subjective and even arbitrary nature of defining ranges on some cost and morbidity impacts. In this thesis the ICIM had to be run after the data was known, and therefore it may have influenced the analysis.

In a different setting with less detailed data, and perhaps where ANC programmes are more different to the W.H.O. programme, more difficulties will be faced in predicting incremental changes, thus probably leading to greater inaccuracy. Comparing the activities of the W.H.O. programme and current practice requires highly detailed data, including surveys and observations (as opposed to reading national guidelines) as well as expert opinion.

9.4.5 Regression analysis predictors method

Only cost per pregnancy and incremental cost were predicted using regression analysis. There was some uncertainty about how this method would perform, given the different levels of predictive accuracy of previous studies. Also, no previous regression analyses were found that modelled cost per pregnancy to allow comparison of significant variables and coefficient sizes between studies. For within country cost predictions, this method was expected to perform well, in that it takes into account complex cost relationships, it is based on expectations of economic relationships, and there was a large and high quality data sets available. However, the expectation of the accuracy of the between country predictions was dependent on whether cost determinants were similar between countries, including patient and provider characteristics and price levels. Following the results of chapters 6 to 8 it was thought unlikely that cost predictions between country would be accurate, even when adjusting for differences in price levels.

This chapter has shown that within country ACPP predictions were not as close to observed cost as was expected (or hoped for). Incremental costs were found to be

accurate, due to the minor differences in variable values for each trial arm. All cost predictions were accurate, using the definition of 'overlapping confidence interval', but this was due to the wide confidence intervals, thus exposing a weakness of this definition. For example, the range for woman 1 in Cuba was US\$225 to US\$5634. Therefore, it did not seem meaningful to make conclusions about accuracy using these ranges. In fact, the lower ranges were found to be unfeasible. For example, woman 1 (with normal number of ANC visits and normal delivery, hospital admission and neonatal admission) is unlikely to incur a cost as low as US\$225.

In terms of % of observed cost, ACP predictions were closest to observed cost in Thailand (94% in control arm) and lowest in Cuba (60% in intervention arm). This chapter has also shown that between country predictions were less accurate than within country predictions, as expected. Accuracy did not improve substantially when adjustments were made for differences in price levels between countries, using staff salaries as the price comparison. This was largely because price ratios and cost per pregnancy ratios between country were very different. However, the approximations of price levels may have been unsatisfactory representatives of health sector price levels, first as PPPs were not health care-specific, and second as staff price ratios between country were different from other resources (see Table 7.8).

Whilst the tests for best-linear unbiased estimators (BLUE) were applied and found to be generally acceptable, several criticisms can be levelled at the model and data. First, some independent variables could not be included that may have influenced either unit costs or health service use, due to lack of data or difficulty in quantifying them. For example, while 'practice style' was concluded to be an important cause of within and between country variation in health service use, it could not be quantified for inclusion as an independent variable. Second, there was overlap in the influence of some variables, such as between 'adverse diagnosis at labour' and 'malpresentation at delivery'. All variables in the final model were examined for multicollinearity, and Pearson correlation coefficient were considered low enough to warrant retaining all variables in the final model. Third, some significant variables had rather doubtful connections to cost, such as postpartum syphilis, which would not have been picked up in average costs, and does not typically cause a longer length of stay. Therefore, this

result may have been a spurious finding or indicates that women with postpartum syphilis are more likely to use health services for other reasons. Fourth, the way some variables were defined may not have allowed their true effect to be captured. For example, the variable 'adverse outcome' contained some morbidity which may not have had a significant cost-increasing effect, such as mild sexually transmitted diseases. The effect of this is to underestimate the true effect of the cost-driving adverse outcomes contained within that variable. Fifth, the 2-way analysis of determinants of cost per pregnancy gave some significant variables that the regression did not find significant. For example, in Cuba some risk factors were shown to be related to cost per pregnancy, including previous stillbirth and previous surgery on reproductive tract. Subsequently, these variables were run in the final regression model to check whether they were significant, and if not they were excluded. The most favoured explanation for this occurring is that variables become insignificant due to their interaction (or duplicate effect) with other variables, which the multivariate analysis can capture.

Sixth, it could be mentioned that alternative functional forms such as logit/probit or the Cox model were not compared with the OLS regression. However, as the OLS model was concluded to perform relatively well, it was thought unnecessary to use different functional forms. Seventh, alternative analysis options could have been used, such as separating high and low cost cases, and evaluating separately. However, as the purpose is to predict cost per pregnancy mainly from a priori factors, it is most useful to now cost determinants (for example the predictors of high cost) at the population level as opposed to the sub-group level.

Dudley et al (1993) found that the accuracy of predictions of mean, median and % high cost patients varied between models: the OLS predicted mean cost most accurately, the Cox model predicted the median cost most accurately, and the logistic model predicted the % high cost patients most accurately. They also showed how much case costs were affected by small differences in values for clinical and age parameters. Therefore, cost predictions from regression analysis can be highly accurate and unbiased if the right model is used.

9.5 Interpreting cost prediction results in South Africa

Given the preceeding results on the accuracy of different cost prediction methods, this section evaluates which methods and data sources are most likely to be accurate in South Africa. Several methods were found to be accurate in predicting cost per pregnancy. Given the findings in Chapters 6 to 8 concerning the magnitude of unit costs and health service use, and the findings of the cost predictions methods for the control arm in South Africa, it is likely that cost transfers of the intervention arm from Cuba will be accurate at nominal exchange rates. Using direct transfer, an ACPP of US\$372 is predicted in South Africa in the intervention arm, giving an incremental cost of US\$25 (US\$372 minus US\$347). This may seem quite a reasonable prediction, given that both health service use and unit costs may increase for some aspects of care in South Africa under introduction of the W.H.O. ANC programme (from the ICIM method). However, it could also be argued that such a result, if accurate, is a fluke, especially as direct transfer of cost per pregnancy using MCPP or at PPPs would give a much less accurate prediction. Therefore, while potentially accurate, the direct transfer method is unreliable for predicting costs in South Africa from the study countries. This conclusion is supported by the findings of the adjusted transfer method, where the transfer of unit costs from Cuba results in a higher ACPP prediction in the intervention arm (of US\$465) which represents over US\$100 increase, which is unlikely in the South Africa setting. On the other hand, transferring health service use from Cuba gives an ACPP prediction in the intervention arm of US\$453, which is a small incremental cost from US\$347 and more likely than US\$453. From Thailand, adjusted transfers lead to a significant reduction in ACPP in South Africa, which is unlikely.

While the staff method is accurate for predicting ACPP of the control arm in South Africa (within 2% of observed ACPP), there are no local intervention arm health service use data to apply to predicted average costs. Therefore, health service use data would have to be transferred from Cuba or Thailand to predict ACPP in the intervention arm in South Africa. This would lead to the uncertainties inherent in the adjusted transfer method, and predictions should be interpreted in the light of these uncertainties. Likewise, predicting ACPP in the intervention arm in South Africa using the regression model requires values to be entered in the model for the variables, if different from the control arm. Each variable in the model could therefore be evaluated in terms of whether

a change is likely under the W.H.O. ANC programme. Variables in Table 9.4 that may feasibly be different include the proportion of women reporting before 20 weeks gestation, rates of referral, rates of postpartum syphilis, hospital admission rates, and possibly CS rates and neonatal admission rates. Therefore, alternative values would have to be predicted for these variables, and entered in the regression equation to predict ACPP in the intervention arm. However, the general problems with the regression model have already been discussed, in particular the fact that for all countries it underpredicts observed cost (predicted cost was only 78% of observed cost for the control arm in South Africa). Therefore, while the cost prediction may not be very close to the true cost of the intervention arm in South Africa, the coefficients do provide some indication of the size of change expected from small changes in variable values.

Finally, the incremental cost impact method was found to be accurate in Cuba and Thailand, although differences were economically significant in Cuba. While random variations between trial arms could not be accounted for in the ICIM (which were partly responsible for the differences between predicted and observed costs in Cuba), it was concluded that ICIM is the most reliable method when there are detailed data present to make assessments of likely impacts on health service use and unit costs. Reliability is enhanced when local health care providers and/or policy makers are involved in its' application. In South Africa, the ICIM predicted that costs would rise by US\$6 to US\$353 under the W.H.O. ANC programme, with a range US\$337 to US\$371. Whether the US\$6 extra cost would be experienced depends critically on whether (a) ANC visits were reduced by 1.7 visits, (b) ANC visit average costs increased by an average of 30%, (c) inpatient admissions for severe UTI and HDP increased slightly, and (d) CS rates, postpartum length of stay and neonatal admission rates do not increase in the intervention arm. Ranges for the first three of these were provided, and was responsible for the range in incremental cost of -US\$10 to +US\$24. However, taking into account breakdown in the assumption (d) may make this range even wider, and change the base case ACPP prediction. However, there was no reason why (d) would not hold for the sample population. Therefore, in conclusion, while other cost prediction methods gave ACPP values within these ranges predicted using the ICIM, the ICIM results are likely to be the most reliable. However, there are other issues to take into account, which are discussed briefly below.

First, the issue of generalisability to the whole pregnant population of Umlazi Township has already been raised, and is an important issue for policy makers. The sample is unlikely to be fully representative of the whole pregnant population. Therefore, these predictions are based on the caveat that they refer to a similar sample as the control arm in South Africa. However, data are not available on the proportion of women who did not attend ANC at all in Umlazi Township, although an estimated 40% of women do not deliver in health facilities⁸⁷. Therefore, the 'missing' population from the data sets may have more adverse events and use less services, and therefore change the average costs per pregnancy actually measured as well as predicted in the study setting. The problem for policy makers is that less is known about this missing population, and therefore their ACPP may have a substantially wider range.

Second, there are issues of initial investments in health systems to make the W.H.O ANC programme work as it was intended. For example, clinics must be equipped to do a rapid syphilis test and also a hand-held doppler, as shown in Table 9.2. Also, staff must be trained in the philosophy and contents of the WHO programme; and incentives must be created for compliance by both health care providers and patients. Also, services may need to be restructured to allow for likely changes in referral patterns, such as more risk cases and deliveries dealt with at health centre level, due to recent overcrowding of referral facilities with low risk cases in Umlazi Township (CHESS 1996). This would require standardisation of management and referral protocols, which are currently not standardised (CHESS 1996), and which is responsible for delay in referral for hypertension and valvular heart disease (Moodley et al 1998). If more deliveries take place at health centres, unit costs would reduce significantly, and thus cost per pregnancy⁸⁸.

Third, low quality of care was raised as a serious concern among health care providers in the participating health facilities in Umlazi Township. For example, nurses

⁸⁷ This figure is based on the pilot study for the W.H.O. antenatal care trial, where only 160 out of 250 women recruited before delivery had their delivery in a health care institution (personal communication Professor Ross, CHESS, Durban, 1996).

⁸⁸ A survey recorded that 36-50% of deliveries at Prince Mshiyeni hospital could have taken place in health centres, but that 90% of women said they would be willing to use the 24 hour clinic service if it was provided (Ramdas et al 1996).

complained that there are too many patients to devote adequate time to, including pregnant women. Although nursing guidelines and maternity care manuals exist, nurses do not have the time to provide the quality of care that they are trained to. Therefore, in order for the W.H.O. programme to have its' full effect, norms of staff:patient ratios should be set and adhered to (Chess 1996), thus requiring large initial investments in staff, and possibly leading to larger increases in unit costs than those predicted in the incremental cost impact approach.

In conclusion, the cost predictions made for the W.H.O. ANC programme in South Africa in this study are clearly a starting point as opposed to a finishing point. The issues raised in the cost prediction process, combined with the further issues raised above concerning the unsampled pregnant population, initial investment and quality of care, leads to the conclusion that the dynamics of different impacts needs to be assessed in more detail by local health service research teams who are responsible for budget allocation and planning services, and that they can use this analysis as a point of departure.

9.6 Conclusion

This section first discusses general findings, and then makes conclusions about each cost prediction method. First, the results showed that there was substantial variability in accuracy both *within* and *between* cost prediction methods. This variability was caused by differences between countries in prices and resource use (and thus unit costs) and health service use, as well as the extent to which different cost prediction methods took into account these differences. For example, ACPD predictions using transfer methods tended to be closer to observed cost between Cuba and South Africa than between Thailand and Cuba or Thailand and South Africa. These patterns emerged due to similarities in both unit costs and health service use between Cuba and South Africa, but differences between Cuba and South Africa compared with Thailand. In the latter, inaccuracies were particularly related to differences in the rates and unit costs of caesarean section and the associated longer postpartum average length of stay, as well as differences in neonatal admission rates (Thailand compared to South Africa) and average costs per neonatal day (Thailand compared to Cuba).

In examining the components of unit cost – prices and resource use quantities per visit – it became apparent that the main inter-country differences were in resource use, in particular staff and drug use. These could be compared between country to examine their influence on unit costs. However, price comparisons were less simple: due to variations in inter-country price ratios for different resources, it was not possible to construct a single price index that reflected price differences (shown in Table 7.8). Two indicators of price levels were chosen to adjust cost predictions - PPP and staff salaries – but neither of these increased accuracy sufficiently to make more predictions ‘accurate’, and some were even made less accurate. Therefore, there were no straightforward conclusions about the extent to which price differences caused differences in unit costs and cost per pregnancy between country. However, the conclusion was made that to make adjustments to cost per pregnancy based on price or GNP per capita levels does not necessarily increase cross-country cost per pregnancy predictions, and may even decrease accuracy.

Another key finding was that, using the definitions of accuracy and economic significance, and given the settings of the study, it was commonplace for a cost prediction to be considered ‘accurate’. However, in some instances predicted and observed costs differed by up to 40%, and were still considered ‘accurate’ due to overlapping confidence intervals. This raises questions about whether the definition of accuracy used in this study is sufficient for policy makers to be confident that the appropriate decision will be made based on cost predictions. For the predictions using predictors from regression analysis, this was especially true, due to the very wide confidence intervals. On the other hand, for a difference to be economically insignificant was rare, as cost predictions had to be within US\$12 of observed cost (in Cuba) and within US\$7 of observed cost (in Thailand and South Africa). Therefore, it often happened that predictions were ‘accurate’ but still differences were economically significant. The cost of an antenatal visit was clearly one of many measures to judge economic significance, and in that sense is an arbitrary measure. These results are important findings of this study, and are discussed further in the next chapter.

The main conclusion regarding the data transfer methods to predict costs are that they are generally unreliable, unless either (a) components of cost are known not to vary

substantially (thus 'allowing' a direct transfer without cause for concern) such as was the case between Cuba and South Africa, or (b) cost determinants are known, and adjustments are made based on these determinants to improve accuracy. Therefore, cost predictions are generally safer if they are based on informed judgement about expected changes in *both* health service use rates *and* average costs. However, even when differences were known, because they occurred in both unit costs and health service use, adjustment of only one of these lead to predictions not being accurate. This suggests that an approach using local data is important to achieve accurate cost predictions when several cost components vary between countries. For this reason, the incremental cost impact method was found to be the most consistently accurate method for both Cuba and Thailand. The degree of confidence in the results was high because local unit costs and health service use levels were used in the calculations, and adjustments were made for expected changes based on detailed analysis.

However, the incremental cost impact method relies on a string of assumptions and/or highly detailed data in order to predict changes in health service use, morbidity rates and unit costs. Even with the detailed data available to this study, some of the assumptions made for Cuba and Thailand proved to be incorrect when predicted impacts were compared with observed impacts. For example, there was no average cost change observed in Cuba due to the W.H.O. ANC programme, although the costing instruments may not have been sensitive enough to pick up marginal changes. Also there were changes in inpatient admission rates and lengths of stay that were not predicted, especially in Cuba (although these changes were not necessarily ralted to the impact of the new programme). In conclusion, the incremental cost impact method assesses changes on a hypothetical level, and uses health systems data that may not reflect actual practices or allow real changes to be pinpointed.

The main finding regarding the use of staff costs to predict average cost for health services is that it is a potentially accurate method, but also substantial variability was found in many of the predictions at the health facility level, thus making it a particularly unreliable prediction method for small sample sizes. This is likely to be due to inaccuracies in both prices and resource use, as average salary levels may not reflect actual salary levels in any given health facility, the proportion of staff and direct cost in

unit cost varies between health facility, and identification of full-time equivalents may not reflect the true staff costs. Therefore, until further work is conducted on this method it is not recommended as a reliable means of predicting average costs, and estimation is advised using a more complete picture of resource use.

The main finding regarding the use of cost predictors from multiple regression analysis is that it identifies multiple influences on cost per pregnancy simultaneously. Also, it was found to be more accurate for identifying cost changes associated with small changes in independent variables (i.e. incremental costs) compared with overall prediction of cost per pregnancy. However, inaccurate or incomplete data may mean that predictors are less efficient, and interaction terms cannot be included, and therefore cost per pregnancy predictions were less than observed cost for all within-country predictions. Also, the differences in significant variables between countries suggest that results are not generalisable between countries, unless (a) through chance, as possibly happened in the case of Cuba and South Africa or (b) cost determinants are identical.

In conclusion, different cost prediction methods can be used depending on the context of the research, including the aims of the cost prediction, the research funding, data sources and availability, data quality and skills available for the cost prediction, and key differences between health care settings. Cost transfer is particularly useful when research resources are very limited and/or when settings do not vary substantially (such as practice patterns, staff productivity ratios, prices). However, when using this method, the cost boundaries, cost valuation techniques, and the degree of uncertainty in the original study should be clear. If cost data are disaggregated, and with some local data, adjustments are possible to increase accuracy. When settings vary with respect to several cost determinants, and data are available on the base conditions (under current care), the incremental cost impact can be used to provide a more reliable, but not necessarily highly accurate, cost prediction. However, the analyst must be especially aware in this method that they are not influenced by expectations, and that realistic ranges are given to reflect uncertainty. Finally, when several inter-related cost determinants exist, and where resources are sufficient to collect (if not already available) and analyse the data, regression analysis can be used to identify cost relationships and predict costs. However, this method is only truly worthwhile when the analyst is confident that there will be

important benefits (such as added understanding of costs or accuracy) over and above the other cost prediction methods. Therefore, the analyst is advised to spend time considering the advantages and limitations of the alternative cost prediction methods, to make an informed decision about which is/are optimal.

10 DISCUSSION

The last four chapters have addressed the empirical objectives, and presented the costs of aspects of maternity care in Cuba, Thailand and South Africa; tested these costs for robustness and presented measures of variability; analysed costs to understand causes of variation; predicted costs in each country using a range of methods, validated predicted costs against observed costs, and drawn conclusions about the strengths and weaknesses of each method. This chapter examines important methodological issues and choices with respect to cost prediction that have been raised in this thesis, drawing on both the literature review and data analysis chapters, and considers the wider policy implications of the results. The first section discusses choices that must be made in predicting costs, choices that determine not only the accuracy of cost predictions, but also their usefulness to policy makers in different settings. These choices include the cost boundary, the measure of central tendency, valuing resources at opportunity cost, the currency conversion method, and sampling and data issues. The second section critically examines the approach used in this thesis to judge the performance of the cost prediction methods, and the cost prediction methods are examined with respect to whether they are likely to perform better or worse under alternative performance measures. The third section appraises the approaches to examining cost variation, including how much economic theory contributed to the cost analysis, and how much methodological and data constraints in analysing data reduced the strength of the conclusions. Also, the interpretation of cost variability and cost uncertainty, and the ability to quantify these appropriately, are discussed. The fourth section discusses the policy implications of the cost prediction methods and results in planning maternity services in the study settings and lower-income countries.

10.1 Choices in predicting costs

Before predicting costs, analysts should be aware of the choices or issues to consider in cost prediction. While these choices must be guided by the ultimate purpose of the cost prediction as well as research constraints, it is useful to clarify the options, and the advantages and disadvantages of each.

10.1.1 Costing boundary

The choice of which costs to include is essential in both measuring and generalising cost evidence between settings, and can critically influence study conclusions (Torrance et al 1996)⁸⁹. This study focussed on prediction of cost per pregnancy, as well as its' components unit costs and health service use. It is therefore recognised that if the study boundary had been different, different conclusions may have been reached. For example, if the costs of neonatal care had been excluded in Cuba, the cost saving in the intervention arm of US\$42 would have been US\$12 greater than in the base case analysis, leading to a conclusion of statistically significant difference between trial arms as well as a less skewed cost distribution. It is also recognised that in other settings there may be other health services that vary between trial arms, such as the number of home visits or private health care visits, or in the costs of care following hospital discharge after delivery. For example, if women are not happy with receiving fewer antenatal visits under the W.H.O. programme, they may choose to attend private clinics as well. The implication is that case cost should be defined to include all important and relevant costs, and where they can be attributed to the intervention (Johnston et al 1999), particularly those costs that vary between two or more health care alternatives.

10.1.2 Average or marginal cost

In measuring and predicting cost per pregnancy, a choice is also faced concerning whether the unit cost should be measured using all resource ingredients or only variable ingredients. The distinction between marginal and average cost is important from both the analytical and policy standpoints, because a unit of production should sometimes be assessed at its' marginal cost, and at other times at its' average cost (Luce and Elixhauser 1990). At the patient level, when small changes in the health system are considered, it can be argued that marginal costs are of more interest than average costs. The rationale behind this is that, when an additional patient is treated, the 'true' cost (opportunity cost) is the change in resource use, involving only variable inputs, and not the average cost which usually contains an element of fixed cost. Therefore, in the short-term, the average cost is not saved when throughput decreases by one unit.

⁸⁹ The types of health care included in cost per pregnancy were defined by the clinical study design, and included outpatient and inpatient ANC, delivery care, postpartum and neonatal care until hospital discharge.

However, the BMJ economic evaluation guidelines argue that the choice over which cost to use in economic evaluation is related to the context and time frame of the decision (Drummond and Jefferson 1996). In the short run few costs may be variable if a change in treatment is introduced, whereas over longer periods all resources, including buildings, can be switched to other uses (Drummond and Jefferson 1996)⁹⁰. However, as well as opportunity cost varying according to time period, the 'next best' use of resources also varies by setting, as the ability to redeploy resources may vary between settings (Drummond et al 1997, Coast et al 2000). The implication of this debate is that cost increments or cost savings of the new ANC programme in the short-, medium- and long-term depend on the policy context. For example, in the short-term in Cuba, other types of patient may not 'replace' the reduced ANC visits saved by pregnant women attending the W.H.O. ANC programme. Therefore, the savings in this case are purely the variable costs, such as drugs and materials. In the medium-term, if still no replacement occurs, staff and buildings can be put to different uses or made redundant, and in the long-term there is reduced investment in equipment. For these reasons, this study presented, compared and predicted health service unit costs and cost per pregnancy at both average and marginal costs, to represent two extreme viewpoints. However, it should be noted that the choice of cost was shown to make a difference to cost generalisability using the cost transfer methods, as marginal costs were a higher proportion of average costs in Cuba, and a lower proportion in South Africa.

10.1.3 Measure of central tendency

In the presence of skewed data sets or non-normal distributions, measures of central tendency other than the mean, such as the mode or median, may be important to present, and also predict. The main variable of interest in this thesis, cost per pregnancy, was found to be skewed (see tables in Appendix 14), although this was reduced to normality or near normality through a log transformation. The advantages and disadvantages of different measures of central tendency are discussed briefly below.

The median cost reflects the 'mid-patient' – that is, the cost per pregnancy of the $(n/2)^{\text{th}}$ patient, where 'n' is the sample size. The benefit of the median value is that the impact of a few very high or very low cost (depending on the skewness) do not have a large

⁹⁰ This viewpoint is also supported by the US cost-effectiveness guidelines (Luce et al 1996) and the World Health Organization (Murray et al 2000).

effect on the measure, and thus allows health services to be directed towards patients with the average cost or characteristics. The median is likely to be useful for primary care providers, as high cost patients are referred to secondary providers; thus the cost influence of high cost women is excluded when transferring cost per pregnancy between primary providers. The problem with the median is that health planning does not take account of high cost patients, and therefore the median will underestimate the resources required for maternity care. In the recognition that the median value may be useful for researchers and policy makers alike in predicting costs, this study evaluated the accuracy of predicted median costs, and they were found to be inaccurate in cross-country transfers by the same order of magnitude as mean costs (in terms of % predicted/observed cost).

The mode reflects the cost value with the highest number of observations. While it is beneficial for the same reason as the median in that it allows health services to be planned for average or low risk patients, again it does not reflect groupings of patients in other parts of the distribution that have an impact on the overall expenditure requirements. An additional disadvantage of using the mode is that it may not even reflect the majority of patients, as the highest number of observations may only be a small percentage of patients. Also, when there exists more than one mode such as it did in study countries, this should be reported in predicting costs as it is of policy interest. The mode is shown in this thesis in the cost distribution diagrams (Appendix 14), but it is not used for predicting costs.

Finally, the mean value is argued to be the most relevant for policy making, for the simple reason that $(n \times \text{mean ACPP})$ equals the total expenditure for the population 'n' (Johnston et al 1999). In cost and cost-effectiveness studies, it is by far the most widely reported measure of central tendency, and most discussion of statistical issues centres on the mean (Bouckaert and Crott 1997, Coyle 1999). In addition, the advantage of the mean is that confidence intervals can be calculated to reflect the range containing a given percentage of observations, with important implications for the comparability of costs and cost generalisability. The disadvantage of the mean, as already mentioned, is that it can be heavily influenced by skewed cost data or outlying cost values. In Cuba, for example, there were 312 patients with a cost greater than US\$1,000 (just over 5% of

the overall sample). While these women were included in the base case analysis, mean cost per pregnancy for women with ACPP of less than US\$1,000 was recalculated, giving US\$300 in the control arm (from US\$406 in the base case) and US\$247 in the intervention arm (from US\$376), a reduction of over US\$100. Therefore, the small proportion of very high cost patients had a large impact on mean ACPP. In addition, policy makers should also be aware of the main cost increasing events. In Cuba, the high cost of a CS and neonatal day meant that women/neonates having one or other of these caused a second mode at around US\$500-US\$600. Therefore, alongside mean values, other data are important in understanding the cost distribution, with implications for predicting and interpreting costs, and therefore in planning health services.

10.1.4 Valuation

Valuation is a critical stage in costing, as conversion to monetary units allows resource use to be summarised in a single easily recognisable and comparable index. However, the approach chosen has potentially important implications for how costs can be interpreted and used, including how generalisable costs are. In this study, the initial aim was to measure costs according to the economic definition, that is, the 'opportunity cost': *"the opportunity lost due to not using the resources in their next best use"* (Drummond et al 1997, page 54). A step-by-step approach for valuation was outlined in Box 5.1, which drew on the development project appraisal literature (Little and Mirrlees 1982, Curry and Weiss 1993, MacArthur 1997). However, while prices were available for all ingredients, a key problem arose in deciding whether current prices reflected the opportunity cost. This was particularly true for non-traded goods, where resource markets were possibly far from perfect. The approach recommended in the development project appraisal literature, that of identifying the 'next best use of the resource', was not used, due to the difficulties inherent in assessing the market for health care resources outside their current uses. Therefore, the extent of the distortion introduced by using financial prices for staff wages, utility and building costs was not known, and possible ranges were tested for the most important resource, staff, in the sensitivity analysis⁹¹.

⁹¹ In Thailand and South Africa private sector wages were substituted as an alternative measure of opportunity cost. However, private sector wages were not considered appropriate for use in the base case as they may include an element of 'rent', as health care workers in the private sector may be willing to accept a reduction in their wages there. In Cuba, take home wages were also unlikely to represent the opportunity cost of labour, because in a communist state welfare services are not charged for (e.g. health care) or are provided at a subsidised rate (e.g. food and clothes rations). However, because the appropriate percentage 'mark-up' from the take-home pay could not be assessed, and no previous research indicates

10.1.5 Currency conversion

This thesis has shown that the currency conversion method chosen has important implications for cost generalisability and the predictive accuracy of different cost prediction methods. The choice of exchange rate to convert local costs into international currencies such as the US\$ depends on what the data are used for. Three possible purposes are identified.

1. To estimate the cost of health care programmes funded by external bodies in their own currency. For example, the UK government wishing to invest in safe motherhood programmes in developing countries. For this, the nominal exchange rate gives the out-of-pocket cost to the funder, at a specified point in time.
2. To compare or pool health care costs between countries. For example, international researchers are interested in relative costs of different interventions in different countries, or they may wish to pool health care costs in a multinational trial. While nominal exchange rates gives the out-of-pocket cost, PPPs provide a better means of comparing costs internationally as they allow judgements about the magnitude of cost as perceived by a local decision maker, as the measure is relative to local purchasing power. In addition, PPPs remain relatively constant through time, and are not affected by transient fluctuations in exchange rates (Drummond et al 1992).
3. To value the contribution of a project to national income, as in development project appraisal, whose aim is to maximise export earnings or national income (Curry and Weiss 1993). For this, the shadow exchange rate is argued to be the most relevant, as it removes distortions present in the nominal exchange rate. However, where nominal exchange rates are determined by the market, as in Thailand and South Africa, no shadow exchange rate needs to be calculated. In Cuba the shadow exchange rate was approximated by the black market rate.

When presenting costs in US\$ in this study, the interpretation of costs depends on the currency conversion method used. Several points are raised with regard to exchange rates used in this study. First, the nominal exchange rate in Cuba is a government-fixed rate (US\$1 equals 1 Peso), and is different to the black market rate of US\$1 = 20 Peso. This suggests that the government rate does not reflect the opportunity cost; however,

the rates, actual wages were used in the base case, and a nominal (though in itself highly uncertain) upward adjustment of 50% was applied.

the black market rate may not reflect the opportunity cost either⁹². Average costs were found to be highly sensitive to this area of uncertainty.

Second, there was a problem of exchange rate fluctuation between the date used for the cost data in the W.H.O. trial (1st January 1998 was the mid-point of the ANC trial) and the date at which the data were analysed (May 1999). This point is particularly relevant to this study, because since the mid-point of the economic study there were significant exchange rate variations in both Thailand and South Africa⁹³. Therefore, exchange rates on 1st May 1999 were used in the sensitivity analysis to reflect this variation, which had substantial impacts on average costs.

Third, the generation, use and interpretation of the PPP measure are also important to consider. In this thesis, a 'home made' measure of PPP was estimated for all countries to allow consistency in comparisons between countries, as PPP rates from international sources were not available for Cuba. A problem with the use of PPP in this study as well as more generally is that its' measurement can rarely make price comparisons using identical items in each country (same quality, size, etc) (World Bank 1997). Also, the 'bundle of goods' contained some imported items, as few food products were grown in all three countries⁹⁴. Health care-specific PPPs have been used by some authors, as they have been found to be different to general PPP measures (Van Ineveld et al 1993). However, these were not available for all study countries. Therefore, the 'home-made' measure was considered to be most appropriate for this study (details provided in Appendix 4 Table 4.1), and allowed conclusions to be drawn about the relative cost of alternative types of care in different countries, as well as the overall costs of pregnancy. Interestingly, rather than reduce the differences between countries at nominal exchange rate, using PPPs actually increased some differences, with implications for direct transfer of costs between countries with similar GNP per capita. For example, cost

⁹² The shadow exchange rate used may be unrealistically high as luxury items and also many necessities can only be bought in US\$ and therefore creates high demand for US\$.

⁹³ In Thailand, this was due initially to unrealistic expectations of future growth (where US\$1 = 30 Baht in 1997), followed by a stock market crash, which caused a massive devaluation of the Thai Baht to over US\$1 = 60 Baht (in 1998), followed by slow recovery throughout 1998 and 1999 (US\$1 = 37 Baht). In South Africa, the Rand was affected by the Asian economic crisis, but the impact was delayed, and between 1997 and 1999 the Rand depreciated from US\$1 = 4.9 Rand to over 6 Rand.

⁹⁴ However, whether goods are imported or not, the PPP measure reflects the cost of commonly bought food items, and therefore reflects the local cost of living.

prediction from Thailand to Cuba using the direct or adjusted transfer methods were more accurate using nominal exchange rate than PPP.

The implication of this discussion is that neither of the rates used are entirely appropriate for converting from one currency to another, when costs from different countries need to be pooled or compared. This finding exposes the fundamental problem of any type of currency conversion, that unless there is a methodologically sound method for comparing costs in different currencies, cross-country cost comparisons are likely to give misleading conclusions. However, the reference case does not provide any guidance on the choice of exchange rate (Weinstein et al 1996). Nominal exchange rates are not entirely appropriate or useful because they do not reflect the cost to local economies, as well as the fact that exchange rate volatility changes the 'international' value of local currencies over time. The general PPP, on the other hand, was based on subjective comparisons between the cost of a bundle of goods, and these comparisons may not apply to the health care market. Therefore, these issues throw doubt on the cross-country comparisons and analysis of costs, and cross-country cost generalisability. Therefore, whilst the cross-country cost comparisons allowed some conclusions about cost determinants at an international level, analysts should exercise caution in interpreting costs when currencies are converted into a common currency such as US\$.

10.1.6 Sampling and data issues

Alternative cost prediction methods were shown in Chapter 9 to require different levels of detail and draw on different data sources. Economic evaluation and costing guidelines advise that costs should be disaggregated by unit cost and health service use. This study explored in detail the determinants of cost per pregnancy by analysing cost components (unit costs and health service use) separately. Also, unit cost behaviour was analysed by separating unit costs into prices and resource use. In fact, four of the five cost prediction methods required disaggregation of components of cost per pregnancy: the adjusted transfer method, incremental cost impact method, simplified staff cost method, and the regression method. Out of these methods, only the adjusted transfer method could be applied without breaking unit costs into prices and resource use⁹⁵. Therefore, the more reliable cost prediction methods depend critically on data being

⁹⁵ However, the regression method could have excluded unit cost determinants (such as staff productivity), but less of the variation in the dependent variable would have been explained in the regression equation.



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approximating unit cost using staff costs alone, staff costs were scaled up by two multiplication factors (% staff costs and % direct costs in unit cost), thus leading to more accurate predictions of unit cost.

In conclusion, not only should the cost prediction methods tested here be evaluated in other countries and health care contexts, but also there exists scope for testing other methods of cost prediction, to increase the comprehensiveness of conclusions regarding the strengths and limitations of alternative cost prediction methods.

10.2 Judging performance of cost prediction methods

This thesis judged the cost per pregnancy predictions using two main measures. The first related to whether the predictions were accurate – that is, the extent to which predictions reflected observed costs. This was reflected or judged in three ways: the US\$ difference, predicted cost as a percentage of observed cost, and whether confidence intervals for predicted and observed cost overlapped. The third of these was used to make the final judgement about accuracy. The other measure for judging the cost prediction methods is whether the inaccuracies observed were economically significant. Therefore, this study recognised that statistical significance cannot be equated with economic significance (McCloskey and Ziliak 1996). While it was recognised earlier that economic significance is a highly context-specific concept, depending on a variety of factors, this thesis also had to choose a measure that could be applied consistently in a variety of settings and that allowed preliminary conclusions about economic significance. This section critically appraises the measures of accuracy and economic significance chosen, and whether different conclusions could have been drawn if different definitions had been chosen.

10.2.1 Accuracy

In using 95% confidence intervals, conclusions about accuracy were based on widely accepted norms of statistical practice. By judging accuracy on the basis of whether confidence intervals of predicted and observed cost per pregnancy overlapped, conclusions were made (with at least 5% confidence) whether the mean values of predicted and observed costs were either the same or there was a reversal in outcome. However, three initial problems with the use of confidence intervals to judge accuracy are noted. The first problem was that some methods did not generate confidence

intervals, but instead ranges, because the predictions were not based on many observations of patients. Both the simplified staff method and the incremental cost impact method generated ranges based on alternative values for variables in the cost equation. This leaves the methods open to manipulation, and therefore the possibility of generating very wide confidence intervals to ensure an 'accurate' result.

The second problem was that some methods generated such wide confidence intervals that an accurate result was found even when the predicted cost was a small fraction of observed cost. This was found in the regression analysis results, where the use of lower and upper confidence intervals on all significant coefficients simultaneously calculated very wide confidence intervals on predicted cost per pregnancy. Conversely, the fact that cost per pregnancy was calculated from large samples gave narrower the confidence intervals than would have occurred under smaller samples, thus reducing the chances of overlapping confidence intervals, and thus creating incentives for small sample sizes.

The third problem was that often a cost prediction method was found to be inaccurate for cost per pregnancy but accurate for incremental cost, thus not allowing a final conclusion about whether the prediction method was accurate or not. In this case, it depends on which type of cost the researcher or policy maker is interested in. If only incremental costs are required, then some methods could be judged to be accurate and therefore usable for cost predictions. However, this thesis did not calculate costs under a do-nothing alternative, the approach advocated by Murray et al (2000) for estimating the average cost-effectiveness ratio, as there was no do-nothing alternative in the W.H.O. ANC trial. A fourth problem is that of test-retest reliability. If a different researcher had conducted the same analyses for some cost prediction methods (those that give the analyst more discretion, such as the incremental cost impact method and regression analysis), different results and conclusions may have been obtained. This is due to the sometimes subjective nature of the cost prediction techniques, where boundaries and types of cost predicted must be chosen, and ranges of cost impact decided in the absence of cost distributions.

In these cases, where there is some doubt about whether the ranges on cost reflect quantifiable confidence, it may be wise to use a series of measures in combination, so

that conclusions of accuracy cannot be made when predictions are clearly not sufficiently close to observed cost, and likely to give misleading conclusions. Two initial options are proposed. The first is the use of another measure of accuracy, such as predicted cost as a proportion of observed cost, with the use of a arbitrary cut-off point to judge accuracy, such as 80-120% or a stricter 90-110%. This approach implicitly ignores confidence intervals, and is useful when confidence intervals or ranges do not contain the information to make conclusions about accuracy. Referring to Appendix 16 Table 16.3, some conclusions about accuracy would have changed using this measure. For example, the simplified staff method predicted costs to within 76-77% of observed cost in Cuba and over-predicted observed costs by 136-147% in Thailand. In both these cases the use of the '80-120% criterion' for accuracy lead to a reversing of the conclusions. Also, the conclusions of accuracy in the within country cost predictions using regression analysis would have also been reversed in Cuba (60-72%) and South Africa (78%), although in Thailand the predictions using the regression model were more accurate (81-94%). All the inter-country cost predictions would have become or remained inaccurate.

The second solution to overcome the limitations of relying on confidence intervals to judge accuracy is to avoid any judgement of accuracy using statistical methods, but to judge cost prediction inaccuracies using an economic measure of significance. This approach is supported by the argument that policy makers are not always necessarily concerned with 95% or even 90% probabilities in cost savings or increments occurring, as they may be less risk averse than statisticians. For example, they may be willing to accept 80% probability of a cost saving and a 20% probability of a cost increment. Therefore the use of statistical analyses, and judgements based on statistical theory, have less practical use when it comes to making changes in policy. In this case, the significance of a cost difference could either be based on different significance levels (based on the risk aversity of policy makers), or based on an economic measure to inform them the mean cost saving or cost increment. This is discussed further in section 10.2.2.

10.2.2 Economic significance

Ultimately, economic significance should be based on whether an inaccurate cost prediction would be likely to lead to a different decision that that which would have

been made if costs were predicted accurately (or alternatively if costs were observed). In the context of this thesis, it means: “would a decision about which ANC programme to adopt be different if an inaccurate prediction was made instead of an accurate one?” For example, directly transferring Thai cost per pregnancy in the intervention arm to Cuba using nominal exchange rates leads to an inaccuracy of US\$286 per pregnancy. Also, directly transferring Cuba cost per pregnancy to South Africa leads to an inaccuracy of US\$19 per pregnancy. The key question concerns whether policy makers in Cuba or South Africa would make a different decision concerning the frequency or content of health care using these data compared to using data on observed costs. However, there were several problems with this ‘decision change’ approach that prevented it from being applied in this thesis. First, there are measurement problems: even if managers were surveyed about what cost changes might affect their decisions, it is not sure whether their answers would reflect what they actually do. Also, what they actually do is difficult to measure until policy changes have been observed over time, which was beyond the scope of this thesis. Second, policy makers will vary between institutions and country and over time, thus making it very difficult to make a consistent judgement about economic significance even across a small sample of providers. Third, decisions of policy makers depend on many complex and inter-related factors that cannot easily be determined or generalised. Decisions may, for example, depend on a mix of political will, time of year with regard to budgeting, budget over- or underspend forecast, staff availability to implement changes, etc. Therefore, the accuracy of the cost prediction is only one of many issues policy makers need to consider in health planning.

For these reasons, this thesis chose a simple and easily applicable definition of economic significance - more than the cost of one ANC visit (averaged for each country) – instead of attempting to model complex decision making processes. This definition was chosen because ANC is the focus of this study, and also local cost levels are taken into account in each country. However, there were also several problems with this definition. First, economic and statistical significance rarely agreed, in that most of the time differences were economically significant, but a lot of predictions were accurate. This introduces the problem that predictions that are not statistically different from observed costs at the 95% level cannot be economically significant, as it could be argued that the difference may not actually exist. This again raises the point that policy

makers may be willing to accept different significance levels than statisticians. Second, as in the case of judging accuracy, the inaccuracy of some prediction methods were economically significant for cost per pregnancy but economically insignificant for incremental costs. For example, adjusted transfer from Thailand to Cuba was highly significant economically for cost per pregnancy (over the cost of 18 ANC visits) but economically insignificant for incremental cost (<1 ANC visit).

Third, the measure chosen had different relative values in all countries. The relative cost of an ANC visit compared to cost per pregnancy varied from 2% in South Africa, to 2.8% in Cuba, to 5.6% in Thailand. Compared to the cost of a normal delivery, an antenatal visit was 23% in South Africa, 26% in Thailand, and 57% in Cuba. Also, the US\$20 per woman cost saving in Thailand was 19% of the cost per pregnancy in the control arm, compared to the cost saving in Cuba of US\$30 only having a 7.5% impact. Therefore, relative costs and cost savings differed between country, and therefore economic significance as measured in this thesis had different interpretations.

Fourth, the measure chosen to conclude whether inaccuracy was economically significant varied within as well as between countries. For example, the cost of an ANC visit varied from US\$8.3 to US\$18.4 between policlinics in Cuba (average US\$12), and from US\$3.6 to US\$9.1 (average US\$6.5) between hospitals in Thailand, and from US\$6.83 to US\$8.63 (average US\$7.24) in South Africa. Therefore, applying health facility-specific ANC visit costs may have lead to different conclusions about economic significance. In conclusion, the weaknesses of the definition of economic significance used in this study suggest that it is better to judge cost prediction methods based on their general performance using a range of definitions and understanding of performance.

10.3 Contribution of cost analysis to cost prediction methods

Cost analysis was discussed earlier as an essential intermediate stage between locating sources of cost data or measuring costs and using these costs in making cost predictions. In understanding components of cost that varied between settings, cost analysis helped explain why direct cost transfers were inaccurate, it increased confidence in making adjusted transfers and assessment of incremental impact, and it guided variable choice in the multiple regression analysis. Chapter 2 outlined the relevance of economic theory

for the health sector, particularly in relation to conducting and interpreting cost analyses of unit costs, and highlighted some difficulties in analysing costs in the health sector. Chapters 3 described and evaluated cost analysis methods, distinguishing between the three components of case cost: health service use, resource use quantities, and prices. Chapter 4 reviewed evidence for the link between cost-determining factors and costs, using the methods described in Chapter 3. Chapters 6-8 all found that the cost analyses used in this study were partially successful in explaining costs (see conclusions in each chapter). However, there were several limitations of approaches adopted in this thesis. These are critically evaluated in four subsections: the contribution of economic theory to the analysis of health care costs; methods for measuring variation and comparing costs; variation left unexplained; and other issues in cross-country cost analysis.

10.3.1 Contribution of economic theory to understanding costs

This section discusses the extent to which the factors identified to cause cost variation could be applied. In general, in presenting different attributes of the cost function Chapter 2 helped provide an understanding of cost behaviour in the health sector, and provided a platform by which to compare and analyse costs. However, there remained some uncertainties concerning how to conduct costs analyses (due to unavailability of key data) and also interpret cost analysis results. First, in the absence of profit maximisation, public health systems were discussed in Chapter 2 and found to be more liable to suffer from X-inefficiency, unless another maximisation condition holds. Although incentive systems, staff motivation, and accountability were not measured quantitatively in this study, nor resource wastage measured in detail to calculate minimum feasible cost (Zuckerman et al 1994), differences were recorded in the regularity of stock taking, recording of resource distribution in the health facilities, and staff productivity. These findings suggest that staff management and efficiency levels differed between health facilities both within and between countries, thus accounting for some cost variation. This finding was highlighted in the results of the data envelopment analysis which showed that technical efficiency was likely to vary between health facilities, due to different output levels from given inputs. However, DEA results should be interpreted with the points in mind that technical efficiency scores did not include all inputs, case-mix differences were not taken into account, and cross-country comparisons could not be made.

Second, returns to the variable factor as a cause of cost variation was identified successfully, as average monthly throughput levels could be compared with optimal (80%) and full capacity (100%) throughput levels. Two particular problems were faced. For inpatient wards, the full capacity for bed days was not equal to [number of beds \times number of days] due to the variable number of beds, as some beds were collapsable or makeshift in nature. Therefore, a large variation was recorded in bed days used per month. It was decided for both inpatient and outpatient departments to approximate capacity as the maximum monthly throughput recorded in the study period. This implicitly assumes that in the months with higher output staffing patterns are not changed to deal with the extra patients. Therefore, the full capacity measure may have overestimated the sustainable capacity, and for this reason 80% was also used.

Economies of scale were recognised in the literature review as a potential determinant of unit cost, as distinct from returns to the variable factor. Without time series data and without controlling for confounding factors (i.e. so that as size increases case-mix does not change, for example), economies of scale are difficult to prove. As time series data were not available, this thesis adopted a cross-section approach, under the assumption that any differences in unit cost at optimal capacity were due to size only, and not due to other factors⁹⁶. The other approach adopted in this thesis, that of comparing % of costs that were incurred by overhead departments, was expected to identify whether larger health facilities had lower % overhead costs. This approach was based on the assumption that most of the efficiency savings as health facilities become larger is in the administrative and support departments. However, the results of this method were unsupportive of the earlier findings in Cuba of economies of scale.

Input mix, or input intensity, was also used to examine causes of cost variation between health facilities, using both monetary and non-monetary comparisons. At the within country level, it was hypothesised to identify whether input intensity or use varied between levels of the system (e.g. primary versus secondary) or within levels of the system. However, it is recognised that any differences identified could have been the

⁹⁶ As all health facilities compared within country were of the same level (policlinics in Cuba and district hospitals in Thailand) such an assumption was not unrealistic. Note that the measure of provider size was different in Cuba and Thailand – in Cuba the provider was the whole policlinic, while in Thailand the provider was the health promotion unit.

result of quality of care, case-mix or efficiency differences, and therefore input mix comparisons served to identify where the cost differences were originating. Due to the multiple input-multiple output nature of health facilities, and due to measurement difficulties, input relationships could not be easily represented or understood. For example, isoquants could not be mapped in two- or three-dimensional space, as six main resource inputs were identified, and for each of these six resources there are many heterogeneous items, thus precluding quantification in a single index. Also, input substitution could not be examined empirically, due to the short-run nature of the research (thus changes in relative prices could not be observed), although it has been claimed that there are limited options for input substitution (Barnum and Kutzin 1993).

The differences in relative prices of resources in the study countries meant that the relation between relative prices and input mix could be examined. Two possible relationships were identified as relative prices changed: one that in the face of limited input substitution, the increase in the price of a resource meant that the cost share of that resource increases; the other that relative price changes lead to substitution. The former was concluded to be the most likely, although empirical evidence was not strong. This is because substitution options between resources are limited: staff roles are very different between countries, but largely defined by historical factors as opposed to marginal relations ($MC = MB$); in antenatal care there are limited options for substitution between staff and equipment, staff and drugs, or equipment and drugs. However, given the higher training level of the primary ANC provider in Cuba (obstetricians) than the other countries (nurses), it could be argued that some ANC in Cuba could be delegated to staff with less training.

The three remaining factors affecting resource use identified in Chapter 2 – economies of scope, quality of care and case-mix – were not examined within country, and these were assumed not to differ sufficiently to cause unit cost differences within country. The assumption of ‘no economies of scope’ was likely to be realistic, as comparisons were between health facilities within the same level of the health system which did not vary with respect to the number of services offered. As the contents of health care were standardised in each country for the control and intervention arms, the assumption of similar quality of care was not unrealistic either. This assumption is supported by the

W.H.O. baseline surveys that found no major differences between contents of care between health facilities, and resource inventories that found that resources were sufficient to provide a minimum quality of care. Finally, whether differences in case-mix were causing cost per pregnancy variations was examined, using 2-way comparisons and regression analysis. However, the absence of a single case-mix indicator made assessment of impact on unit cost difficult.

10.3.2 Measuring variation

The use of confidence intervals in this thesis has been an important aspect of cost presentation, comparison and generalisability. However, as few economic evaluations collect data at the patient level, it is not common to report ranges or confidence intervals in case costs (Briggs and Gray 1999)⁹⁷. In this study, variability was expressed for unit costs, health service use and cost per pregnancy, to make comparisons between health facilities, and ultimately conclusions about the probability that costs varied between health facilities. This was an important first stage before the causes of these differences were sought.

For health service use and cost per pregnancy, the confidence intervals were calculated using data on the patient sample from the W.H.O. ANC trial. These confidence intervals were interpreted as “the population mean is 95% likely to fall within this confidence interval”. However, confidence interval do not reflect the skewed nature of the data, nor is the true size of the sample variability captured by the standard error (whereas it is by the standard deviation). Two options were faced in dealing with this problem (Briggs and Gray 1999): either to transform the data to take into account the skewness, or to calculate confidence intervals using a nonparametric method such as ‘bootstrapping’. The computationally easier approach of log transformation was chosen in this study, and the values for skewness obtained from the statistical package (SPSS for Windows) were reduced to normality in Thailand and near normality in Cuba and South Africa, thus allowing (a) testing of the equality of two means, and (b) use of cost per pregnancy as the dependent variable in multiple regression analysis⁹⁸.

⁹⁷ In their review of economic evaluations reporting QALYs before December 1996, Briggs and Gray (1999) found only 53 out of 492 studies had patient-level cost data, and only 4 reported a 95% confidence interval on cost per QALY.

⁹⁸ Also, the cost distributions were found to be similar between trial arms within country, but not necessarily between country (number of ANC visits in Appendix 5 Table 5.1 and Table 5.2, and cost per pregnancy in Appendix 14 Tables 14.1 to 14.10).

For unit costs, variability was calculated using a different method, as unit costs were not measured for specific individuals, but for groups of patients (including patients not in the trial) receiving specified health services in different health facilities. Therefore other options for representing variability were assessed. The measure chosen was the variability between unit costs for the months of the study period (as unit costs were measured on a monthly basis). This gave confidence intervals for unit cost that represented the 95% probability that the true unit cost would fall within this confidence interval. Therefore, this measure was recognised not to reflect inter-patient variability, and that a large proportion of patients could potentially have unit costs well above and well below that range. However, the measure of unit cost variability did allow comparison of unit costs between health facilities, and whether there are likely to be differences at an average level that includes all patients⁹⁹. Finally, the sensitivity analysis showed the how unit costs altered under alternative assumptions, and the new ranges were used to calculate a new range for cost per pregnancy thus adding to variability and reducing cross-country variation.

10.3.3 Explained and unexplained variation

Using the cost analyses, a proportion of the cost variation within and between countries could be explained, and tables showed that for many health facilities expected levels of unit cost based on the cost analysis results were close to observed unit costs. Staff productivity was found to be the most important determinant of unit cost, as well as occupancy rates and economies of scale in some settings. However, there still remained unexplained variation, for which four causes are discussed.

First, although economic theory was consulted in identifying potential influences on unit costs, it is recognised that the literature review may not have identified all factors that cause variation in costs. Despite this, the approach of this study attempted to move towards establishing a framework for identifying cost-determining factors and analysing costs using accounting methods.

⁹⁹ Also, note that as most of the costs of ANC are from routine procedures, the presence of morbid conditions does not lead to a substantially higher cost per ANC visit: it may lead to (1) a higher drug cost if a prescription is made, and (2) a slightly longer consultation with staff. However, many high risk or unwell patients would be referred or admitted to hospital, therefore not burdening the ANC clinic further.

Second, data were lacking to test all the hypothesised factors. For example, time series data were not available to identify whether economies of scale actually existed; detailed data were not collected to measure resource wastage; a quality of care measure and case-mix indices were not constructed due to lack of data, or complexity and uncertainty of constructing such measures¹⁰⁰. Also, with respect to health service use the sample sizes were not sufficient to make confident conclusions about variations between health facilities. This was true for aspects of women's cost collected from the survey (30 women per health facility) and also case-mix collected from the trial data set. Comparisons were therefore stronger at the 'between arm' and 'between country' levels of comparison. Finally, not all the variability in cost per pregnancy could be explained using the independent variables in the regression analysis, thus suggesting omitted variables.

Third, measurement error may have caused some cost variation. Measurement error is divided into (a) unknown error introduced by health service workers recording the routine data systems or the researchers in extracting the data from the records, and (b) filling gaps when data did not exist for some cost variables. The size and impact of (a) cannot be known or tested for, but in interpreting the data assumptions are implicitly made that no errors were made. The size and impact of (b) can be tested for by substituting alternative values where gaps were filled, and testing the sensitivity of the results. With respect to the health service use data extracted from the WHO trial, there were data collection and data entry mechanisms in place that ensured high quality data, including pre-trial training for local data managers, monitoring visits by W.H.O. staff, monthly report sheets sent to W.H.O., double entry, and follow-up of missing data and cases (Pinol et al 1998). Also, any cases that were lost at or after the delivery period were excluded from the analysis as lost-to-follow-up. Therefore, measurement error in the trial data set was concluded to be minimal.

With respect to unit cost data, there was more room for measurement error, although there were also procedures in place to minimise researcher error. While on the one hand the researchers were highly dependent on the quality of the routine data records, on the

¹⁰⁰ However, even with detailed studies of quality of care, the relationship between unit costs and quality of care may not be determinable (Gilson 1992, Broomberg 1997). Also, diagnostic related groups to reflect case-mix have been found not to reflect cost closely (Tatchell 1983).

other hand the systems and staff were in place in most health facilities to record this data, for purposes of fulfilling monthly reporting requirements. However, there were staff shortages in one or two polyclinics in Cuba leading to incomplete data on throughput and accounting information; in these cases data were generalised from other polyclinics in the same municipality, with adjustments taking into account differences in sizes of polyclinics. Also, in Thailand the incomplete recording of material distribution in some departments of some district hospitals meant that material costs were generalised with adjustments for differences in patient throughput between hospitals.

Fourth, uncertainties in costing methodologies may have caused unit cost variations between health facilities. Therefore, uncertain parameters were identified, likely ranges assumed, and ranges calculated to reflect the unit cost values under alternative assumptions or methods (Briggs et al 1994). However, this thesis suffered similar problems to other costing studies in choosing parameters and identifying an appropriate range (Briggs et al 1995)¹⁰¹. On the whole, this thesis used ranges based on informed judgement; therefore a degree of confidence (e.g. 95%) could not be attached to the resulting intervals. In addition to the problems discussed above in identifying types and magnitude of uncertainty in individual parameters, uncertainty was also faced in the conduct of multi-way sensitivity analysis: in identifying which uncertain parameters to include, quantifying correlation between uncertain variable, and deciding what size of change in the base case causes results to not be robust. Therefore, careful consideration was given to which variables should be included. Also, due to poor data to estimate correlations (such as the change in medication use with increase in cost) and probability distributions, or flat probability distributions (such as for alternative values for opportunity cost), probabilistic sensitivity analysis was not attempted. 'Unacceptable' changes in cost were defined to take place if the new value fell outside the confidence interval provided by the variability estimate.

10.3.4 Issues in cross-country cost analysis

Several issues in cross-country cost analysis have been discussed earlier in this chapter, including choice of currency conversion method, and choice of value to represent

¹⁰¹ According to Manning et al (1996), one of the least-addressed areas of CEA concerned "how to incorporate the inherent uncertainty regarding parameters, relationships and model structure into estimated cost-effectiveness ratios...and then to represent the impact of this uncertainty on the elements of the analysis critical to decision making."

opportunity cost. Several other difficulties were faced in the cross-country cost analysis. First, when comparing resource use or productivity between countries, the outputs or quality of care were not identical. For example, an antenatal care visit may be considered to be qualitatively different between countries, despite the standardising effect of the W.H.O. programme, as staff with similar qualifications receive different training. Hence when comparing visits per FTE, this difference in output quality should be taken into account.

Second, case-mix varied significantly between countries, but was not examined in depth. The analytic methods used were not detailed enough to identify the size of impact of case-mix differences on cost. Therefore, it was unclear how much the differences in risk factors and morbidity between Cuba and Thailand caused the differences in numbers of antenatal visits, and subsequently cost per pregnancy. Third, the main hypothesised cause of inter-country health service use variation, practice style, could not be measured quantitatively, except in isolated situations. For example, the different rates of intrapartum caesarean section suggested that risk aversity was different between country, as these rates should be relatively stable across setting (Villar et al 2000).

Fourth, price comparisons between countries that tested whether they explained unit cost differences should be interpreted in the light of differences between resources. For example, nurses had different tasks and amounts of training in the study countries, and equipment quality varied. Fifth, the static framework of data substitution had limitations. While causes of unit cost variation were sought by substituting resource quantities and prices across countries, this method of analysis did not take into account production function dynamics, such as input substitution under different prices. The degree of input substitution, and thus the elasticity of substitution, was difficult to quantify in the study settings, and therefore allowances could not be made for dynamic effects in data substitution. In conclusion, although cross-country cost analyses were important for assessment of cost generalisability of the W.H.O. ANC programme, the results of the cost analyses should be interpreted with these issues in mind.

10.4 Cost prediction and policy making

In the following section, policy implications are discussed at three levels of decision making, although it is recognised that these may not reflect the full range of levels at which decisions are made. The highest level of decision making is at the international level such as the W.H.O., the World Bank, or multilateral donors such as the UK Department for International Development. While one function of these organisations is to provide direct support to research and decision making at country level, they also devote resources to drawing lessons for cross-country or cross-regional comparisons. This is an important role of international organisations, who have the data sets and technical expertise to make generalised policy recommendations. The next level of decision making is national governments, who tend not only to pursue policies advocated by international organisations, but also have an interest in providing the health services that are most relevant to their population and can be provided within budget. This requires skilful translation of generalised guidelines or policy advice from international organisations to a range of settings that may exist in any one country. A lower level of decision making is the provincial or district level. These levels are the implementation levels for government policies, and therefore determine hospital or health centre budgets and influence expenditure patterns (if this is not done at national level). The following discussion refers to all these levels.

10.4.1 Interpretation of cost results

Economic results from a clinical trial should first be interpreted in the light of the clinical component and health outcomes in their original setting, before cost prediction can be further interpreted and implications discussed. The W.H.O. antenatal care trial offered many opportunities for the economic evaluation, as well as some limitations¹⁰². The trial methods are described more fully in Lumbiganon et al (1998). In brief, the opportunities offered by the trial included a large sample (four country sites; at least twelve participating health facilities within each country; and at least 4,000 women enrolled in each country), health service use data for all enrolees, and a structure of collaborators who helped with the smooth running of the economic evaluation. Also, as the costing study was linked to effectiveness outcomes, issues of allocative as well as technical efficiency could be addressed. However, allocative efficiency could only be

¹⁰² The trial was described briefly in Section 5.1, with more details provided in Appendix 2.

evaluated at the level of mothers and for the health outcomes selected for measurement in the trial, and not for society as a whole (for which all health interventions need to be compared and health interventions are chosen on the basis of comparative cost-effectiveness (Bobadilla et al 1994)).

There were, however, some limitations of conducting a cost study alongside a clinical trial, due to reliance on the trial structure and data sets. First, some types of health service use relevant to pregnant women was not collected in the trial data forms, including home visits and use of private health care. Therefore, it is possible that some small differences between intervention and control groups existed but could not be detected. On the other hand, these differences were known to be minimal in all countries¹⁰³. In addition to these health services, follow up costs beyond six weeks postpartum were not included. The absence of these data, however, was not expected to affect the economic conclusions, due to the finding of equivalence in health outcomes (Villar et al 2000).

Another limitation imposed by the trial was that sample sizes, although admittedly large, were not calculated on the basis of economic outcomes; therefore, it was not known *in advance* whether there was sufficient sample size to make conclusions about the statistical significance of economic differences. Two factors made it difficult to make conclusions about economic differences. First, the skewed nature of the cost distribution cast some doubt on using mean values for comparing costs between trial arms. In this case, log transformed costs were used to validate the t tests performed by the data software package. Second, what constitutes an economic difference could not be objectively defined. Therefore, cost differences were judged using an arbitrary measure of the cost of one antenatal visit to make conclusions about economic significance. The implication is that there was no sound basis for concluding whether or not economic differences existed, and therefore cost differences should be interpreted by those actually making decisions, as opposed to researchers not familiar with the decision making process.

¹⁰³ Except home visits in Cuba, of which there were at least five per woman. However, the trial managed to record all those home visits where an intervention was performed, such as blood pressure measurement, or formal advice outlined in the ANC model, and these were included as antenatal visits.

A third limitation imposed by the trial was that there were constraints to using the bottom-up costing method to calculate unit costs. The implication was that with no patient-specific unit costs there was a missed opportunity for presenting cross-patient cost differences, and enhancing the analysis of cost variation. Several justifications were given for not using the bottom-up costing method in Mugford, Hutton and Fox-Rushby (1998). One significant factor preventing collection of unit cost data on individual patients was that to collect information on resource use measurement at the patient level would have required using either an outside observer or detailed recording by the health providers. While such methods of costing are not unknown, the problem in this context was that data collection may have changed the behaviour of health providers in terms of quality or quantity of care, and it would have imposed data collection costs to the health system. Therefore, there was a risk that resource use measurement at the patient level could have altered trial health and economic outcomes.

As well as the ANC trial structure, cost prediction results should also be interpreted in the light of the economic framework chosen, as results are often highly dependent on the types of cost included. The overall economic outcome, cost per pregnancy, consisted of antenatal, delivery, postpartum, and neonatal intensive care. In Chapter 1, the reference case was discussed as a means by which the comparability and generalisability of cost-effectiveness ratios are increased across health care settings (Luce et al 1996). In this thesis, the reference case was used as guidance for cost inclusions, but was not presented as defined by Luce et al. While all resource ingredients and health service use affected by the intervention were included to calculate cost per pregnancy, there were two main differences with the reference case. First, as mentioned above, home visits, use of private care, and long-term care costs were not included, and these were assumed to be similar between trial arms. Second, patient or wider societal costs were not included in the costs of pregnancy. While patient costs were included in the economic study alongside the trial, they were not analysed in this thesis as provider costs were the focus of the thesis. The policy implications are that, when costs of pregnancy are compared with the costs of other health care interventions using the reference case, the time horizon and range of services should be adjusted to be consistent with other studies, and patient costs and any wider societal costs should be added.

Using these costing boundaries, and based on assumptions previously described, average cost per pregnancy (ACPP) in Cuba was reduced from US\$402 to US\$372 per woman (7.5% reduction), in Thailand ACPP was reduced from US\$106 to US\$86 per woman (18.9% reduction). However, as previously stated, these cost savings may not be enjoyed in full until fixed resources are redeployed, such as being used by other patients who would benefit from them. Also, 95% confidence intervals showed costs not to be statistically different between trial arms in Cuba, and statistically different in Thailand. Given that the trial concluded that health outcomes were similar between trial arm (Villar et al 2000), policy makers are advised to adopt the programme in Thailand where there is a high chance of a cost saving, whereas in Cuba policy makers should be aware that a cost reduction is not guaranteed (at the 95% level).

The debate so far has focussed on observed values. The question also needs to be addressed concerning the implications of cost predictions for policy making. Chapter 10 presented the difference between observed costs and cost predictions, and it was concluded that decisions are likely to be affected by whether observed or predicted cost values are used. Even where cost predictions were concluded to be 'accurate', decisions may still change when predicted values are used instead of observed values. For example, the incremental cost impact method in Cuba was found to be 'accurate', but at least a US\$57 saving was predicted, almost double the observed saving of US\$30. In a hypothetical scenario, a decision maker may react to a US\$57 saving per pregnancy but not to a US\$30 saving per pregnancy. However, the true threshold at which the change in decision occurs is not known, and depends not only on the person making the decision but also how close to year end one is and what budget is left. Other cost prediction methods, such as the data transfer and multiple regression methods, were even more inaccurate than the incremental cost impact method. Therefore, while no overall conclusion is possible due to uncertainties about 'thresholds' at which decisions change when using different data sets, the findings of this thesis suggest that caution is required in using predicted costs in policy decisions where there are limited means of validating these costs.

10.4.2 Wider implications for trial countries

Three particular issues are discussed with respect to using the ANC trial cost results in nontrial settings within country, those of (a) the wider policy context of antenatal care,

(b) cost variability, and (c) cost generalisability. The first is important, because the antenatal care trial may not incorporate all the issues faced by policy makers and how they might wish to use the results, or take into account the complexity of the decision making process. As mentioned earlier, the trial countries and their health systems are classified as those belonging to middle- as opposed to low-income countries. Therefore, while they do not enjoy the same spending levels as richer countries, at least a minimum level of antenatal, essential obstetric, delivery and neonatal care is provided, and in some cases health care provision is above this minimum (Piaggio et al 1998). In fact, the antenatal care trial has collected data that suggests over- or inappropriate use of resources – such as laboratory tests that are high cost and with limited benefit (especially Cuba), the use of obstetricians for some tasks that general practitioners or nurses/nurse midwives could perform equally well (Cuba and Argentina), high levels of inpatient admission in Cuba and Argentina compared to Thailand and Saudi Arabia, higher levels of caesarean section in Cuba compared to the other countries, and high levels of neonatal intensive care admission in Argentina compared to the other countries. While this variability in rates of health service use may reflect practice style differences (due to differences in perceptions of risk at health care provider and/or at national levels), it does suggest that some procedures are used more out of habit than medical need, thus pointing to the potential to reduce health service use in some settings.

Recent events have meant that in three of the four trial countries, Ministries of Health are looking to cut costs or at least to rationalise services¹⁰⁴. In this respect, the W.H.O. antenatal care trial results are of some interest to these countries. However, as the W.H.O. trial has shown, providing information on effectiveness is not sufficient to change policy practice. For example, external cephalic version to reduce the rates of breech presentation and CS were not practised widely in some trial countries, despite being an effective intervention (Villar et al 2000). Another issue relevant to all trial countries is that women in experimental clinics showed some concern about the number of visits being too small and the spacing between them too long (Villar et al 2000). Therefore, policy makers should take account of women's views in deciding whether to

¹⁰⁴ This is due to: economic crisis in Thailand; withdrawal of support by the Soviet Union in Cuba; and the under funding of public health services in Argentina

follow the recommended four visits for low risk women. Policy issues specific to antenatal care are discussed briefly for Cuba and Thailand below.

In Cuba, despite the remarkable achievements in the health sector in terms of reduction in rates of all major disease categories and the equity in distribution of the benefits (Pan-American Health Organization 2000), there is still potential for improving health service delivery in some if not all policlinics in the W.H.O. antenatal care trial. This is suggested in differences in staff productivity levels, and the fact that many of the policlinics were not operating up to their quota of staff, in terms of health staff and key administrative personnel such as accountants and statisticians. Also, the data showed that some equipment such as laboratory equipment and fridges have not been replaced for a long time (some are as old as fifty years), and given the current economic situation in Cuba it is unclear whether these are high priority to replace.

In Cuba, the extent of changes in health service organisation through implementation of the W.H.O. antenatal care programme is not major. One finding of the trial was that the ANC programme could be implemented with no major changes to health care delivery, except for reduced antenatal visits and increased involvement of the obstetrician in visiting the family doctor clinics when a pregnant woman is booked for an appointment. Therefore, the ANC programme accords well with the current Cuban approach to antenatal care (Piaggio et al 1998), in particular the focus on developing the relationship between the health care provider and the pregnant woman; information, education and counselling; risk assessment and referral; and the emphasis on accessible primary health care. In Cuba, maternity homes are still popular, and are used mainly for women from poorer households to reduce stress during the closing stages of pregnancy, those with nutritional deficiencies, and those needing bed rest. This does not go against the W.H.O. ANC programme, although the programme does not actively promote this concept. Finally, HIV rates are very low in Cuba, with 1,468 HIV-positive individuals detected between 1984 and 1996 (in a population of 11 million people), with a larger share male (Ministry of Health 1996). With the operation of the Cuban sero-epidemiological surveillance programme, it is unlikely that antenatal HIV testing is likely to be a major policy issue.

In Thailand, the health system has gone through a massive upgrading during the early and mid-1990s due to economic progress, although since 1996 there has been a slowing of government spending on health sector infrastructure (Bureau of the Budget 1990-9). Maternal and child health has been one area to benefit from this upgrading, with outpatient departments in all district hospitals for 'health promotion' (separated physically from general outpatient departments), consisting of ANC, family planning, school health outreach, and a well-baby clinic. Health centres, the lowest level of care, are managed by the planning departments of the district hospitals (up to ten health centres per district hospital). Health centres also provide ANC, but high risk women are referred to district or higher level hospitals using a detailed risk assessment form in the antenatal card. Like in Cuba, the author observed that the evidence-based medicine approach of the W.H.O. antenatal care programme accords well with the Thai interest in modern medicine at the individual and government levels (although traditional medicine is still practised), and the programme also fits in with the national focus on primary health care in Thailand. One issue Thailand faces, like most countries, is how to slow the spread of HIV/AIDS. Given that roughly 80% of the 16,200 AIDS patients in Thailand in 1996 were male (Ministry of Public Health 1997), and that Khon Kaen province had 404 AIDS patients in 1996, it is likely that under 100 women in Khon Kaen province had AIDS, of which only a small percentage were pregnant. Given these small numbers, it is unlikely that antenatal testing would significantly impact the spread of the disease, and therefore is not a priority public health issue. However, for those women with identified HIV/AIDS, reducing mother-to-child transmission using a short course of zidovudine and using alternatives to breast feeding is a feasible option in terms of cost (Dabis et al 2000). The impact of this policy on the average cost per antenatal visit and delivery would need to be examined.

The second issue, that of cost variability, is important, because the conclusions concerning the strengths and weaknesses of cost prediction methods are based on the average values for each trial arm, and they do not reflect differences between randomised units within arm (see Tables 6.3, 7.4, and 8.1). Therefore, at the individual health facility level, the conclusions about the accuracy of the cost prediction methods would change, with important implications for health service planning for health facilities that fall into the 'high cost' or 'low cost' categories. At the district level, policy

makers should identify whether more hospitals tend to fall into 'high' or 'low' cost categories, for budget-setting purposes. Therefore, policy makers need to collect data on the characteristics of providers found in Chapters 6 to 8 that predict them as high or low cost (size, occupancy, staff productivity, inpatient admission rate, CS rate, neonatal admission rate).

The third issue, that of cost generalisability, concerns what differences may exist between trial and nontrial settings within Cuba and Thailand to reduce the generalisability of the trial results. For the incremental cost per pregnancy results to be the same in other settings within study countries, three assumptions must hold:

- The rest of the country provides ANC in a similar way to the control group in the trial (and therefore has similar unit costs and health service use). For example, if quality of care is lower in other settings, average costs may rise in implementing the W.H.O. programme.
- The WHO programme is implemented successfully, in a similar way to the trial. For example, costs would not be the same if hospital managers adapt the programme to suit their own resource availability.
- Costs associated with the new programme, such as training costs, initial monitoring costs, and friction costs of changing staffing patterns, are short-term and not substantial. This assumption is important, because these costs were excluded from the costs reported in Chapters 6, 7 and 8.

Therefore, in order to examine whether these assumptions are likely to hold, the representativeness of the health facilities in the study countries should be considered. Clinics were chosen that met a set of criteria. Table 10.1 lists these criteria which include both scientific criteria, such as adequate sample size and follow-up, as well as pragmatic criteria, such as the ability of the clinics to implement the new ANC programme. It was also important to have high institutional delivery rate, so that data could be collected for a high proportion of women without incurring expenses associated with follow-up at home. Criteria 1-4 relate to the ability to perform a scientific study; criteria 5-8 relate to the generalisability of the results, and therefore other health facilities within country should be compared using these final four criteria.

Table 10.1: Criteria for clinic selection for WHO antenatal randomised controlled trial

Criteria
1. Each clinic should be able to provide at least 300 new patients in a period not longer than 24 months.
2. Intervention and control clinics will be in the same geographical area, but serving distinct neighbourhoods.
3. All women from these ANC clinics will be traceable at delivery.
4. The follow up mechanism will have access to the hospitals which are the referral place for all high-risk patients.
5. The clinics should be part of a public (or semi-public) ANC system. Military hospitals or social security institutions are also eligible. The study will not include clinics where direct fee-for-service payments are required.
6. All clinics should have an ANC system already in place with norms and predefined activities which are followed.
7. The clinics should be able to implement new simple tests or activities as required by the protocol. Funds for these new activities should be provided by the institution(s), as they will be for direct patient care only. These few new activities will replace several currently implemented.
8. The clinics should have an already working and economically supported minimum staff required for patient care as per the protocol.

(taken from Villar et al 1998, page 34)

In Cuba, policlinics are part of a public health system, where budgets are allocated according to standard criteria, although some inter-regional variation has been found in rates of resource use from government documents. In Havana city, a rate of one doctor per 111 inhabitants was the highest in Cuba, dropping to one doctor per 251 inhabitants in Granma province (Ministry of Health 2000). There was less variability for nurses, with one nurse per 117 inhabitants in Havanna, varying between 100 and 167 in the rest of Cuba. In terms of numbers of policlinics, Havanna contains 20% of the population and 19.3% of the policlinics, and therefore the inhabitants in Havanna are not better served than the rest of the country (although average distance to a policlinic will be less, due to the density of the population of Havanna). In Havanna, the inpatient admission rate for obstetrics of 3.5 per 100 female inhabitants between 15-49 years was close to the national average of 3.3 (variation between provinces of 2.2 to 4.5), while for neonatal admission rates the rate of 22.1 admissions per 100 live births was just above the national average of 20.7 (variation between provinces of 10 to 30). Therefore, these comparisons suggest that average cost per pregnancy may be slightly higher than in the rest of Cuba, due to higher resource and health service use rates, although at the provincial level there is some variation.

Like in Cuba, the participating health facilities in Thailand were part of a public system, where budgets are also allocated according to standard criteria. In fact, a visit was made by the author to Southern Thailand, where three district hospitals (one small, one

medium and one large) were visited. These hospitals were found to be remarkably similar in terms of staffing patterns and activities when compared with hospitals from Khon Kaen province. In terms of inter-regional resource comparisons, the Northeast Region rates the worst in Thailand. In 1994 there were 941 inhabitants per physician in Bangkok compared with 10,900 inhabitants per physician in the Northeast, compared to a country average of 4,192 inhabitants per physician, thus showing considerable inequality in distribution (Ministry of Public Health 1997). On the other hand, Khon Kaen province was closer to the country average, due to the location of the regional hospital in Khon Kaen city¹⁰⁵. A second issue is that district hospitals only account for about 50% of antenatal care provision in Thailand, with health centres and referral hospitals providing the rest. While referral centres were included in this study, unit costs and average health service use were not measured at health centres. This has implications for whether the cost per pregnancy figures reflect costs at other levels where patients receive care. Thus without further cost studies or collection of published evidence, the generalisability of the results to health centres is limited. Given that the variability reported reflects women reporting to district hospitals, the implications are that cost per pregnancy may be different at other levels of care. For example, at health centres in Thailand, the inpatient admission rate and institutional delivery rate may be lower due to less geographical access to hospitals.

10.4.3 Implications for South Africa

In addition to the detailed cost prediction exercise and validations between Cuba and Thailand, this study benefited from cost analysis and prediction in a third setting in South Africa. Not only did the setting in South Africa allow further cost comparisons and cost analyses, but also in the absence of data from a trial, issues in cost prediction were made more 'real world'. The last chapter suggested that the best estimate of the impact on cost per pregnancy of the W.H.O. programme in South Africa should be taken from the results of the incremental cost impact method, as the Cuba/Thailand analysis found the ICIM to be the most reliable. Therefore, in the base case ACPP was predicted to increase by US\$5.65 (-US\$10 to US\$24), leading to an ACPP of US\$352.65 (increase of 1.6%). This increase in cost per pregnancy suggests that the point estimate of the cost-effectiveness ratio enters a different cost-effectiveness 'quadrant' to that of

¹⁰⁵ 1996 data show that Khon Kaen province has 3.6% of physicians in Thailand compared to only 2.8% of the population (Ministry of Public Health 1997).

Cuba and Thailand (Wakker and Klaasan 1995, Laska et al 1997). However, given that the new programme may also involve a US\$10 saving per pregnancy (the lower confidence limit), the cost-effectiveness ratio is not entirely in a different quadrant. Added to uncertainty in incremental cost, the health impact of the W.H.O. programme is uncertain. Although it was not the purpose of this thesis to predict cost-effectiveness in South Africa, it could be speculated that with successful implementation of the W.H.O. programme the primary health outcomes are reduced to nearer the levels in Cuba and Thailand (see Appendix 16 Table 16.2). For example, urinary tract infection may be treated earlier thus reducing severe UTI rates to below 10% from 16%; postpartum anaemia prevalence may also be reduced to below 10% with improved compliance with iron folate supplementation and dietary advice. However, this assumes that the antenatal care programme changes the behaviour of both patients and health care providers.

This discussion about effectiveness is particularly important for decision makers in South Africa due to the uncertainty surrounding whether costs will increase or not, because if health outcomes can also be improved, it could be argued that the additional cost is worth it. Also, there may be some interactions between effects and costs: improved health may lead to lower costs (Willke et al 1998). In addition to these issues, the base case cost results must be interpreted with caution, given that (a) the base case difference is not economically significant, being less than the cost of an ANC visit; (b) there is uncertainty about the true impact on health service use, unit cost and morbidity, due to the assumptions inherent in the ICIM; (c) the ACPP of US\$347 in the control group does not reflect the full pregnant population, due to the hospital-based sample, not taking into account the estimated 20% of births that take place at home, as well as a proportion in clinics; and (d) other issues such as initial investments and quality of care improvements are not considered (this issue is covered in section 9.6). In addition to these issues, there are several current policy issues in South Africa that concern antenatal care, but are not raised in the W.H.O. antenatal care programme, or are raised in a limited way. These are: abortion care, fertility regulation, HIV/AIDS, access to care and other factors affecting health service use, and the main obstacles facing health services in improving the quality of maternity care in South Africa.

Abortion was illegal in South Africa until 1996. In 1994 there were estimated to be 200,000 unsafe abortion in South Africa, with Rands 9.74 million (US\$1.4 million) spent on treating women with unsafe incomplete abortions (Kay et al 1997). With the 1996 law Choice on Termination of Pregnancy, this cost should be significantly reduced assuming abortion services are accessible, acceptable and that there exists public awareness about their availability and safety (Kay et al 1997)¹⁰⁶. Antenatal care could provide an opportunity for informing women of their rights with respect to abortion. However, as few women who are planning to have an abortion are likely to attend antenatal care, the information may be used for future pregnancies.

Second, fertility regulation is being promoted as an important right of people living in a new democracy such as South Africa, whose main aim to reduce unwanted and teenage pregnancies (Health Systems Trust 1996). Antenatal care is also an important time to promote fertility regulation measures, and therefore specific advice would need to be incorporated into the antenatal care programme outlining the available and recommended options for contraception that are relevant in South Africa.

Third, from recent research studies that measured HIV prevalence in antenatal attenders, the true scale of HIV/AIDS is being measured in South Africa. Research studies have shown that in some areas, roughly one in three pregnant women are affected by the virus. Antenatal care presents several opportunities to reduce transmission and improve health outcomes, assuming those found to be infected change their behaviour and do not knowingly put others at risk. These include testing and counselling, information and education about the disease, advice about safe sex, and finally reducing mother-to-child transmission during and after childbirth (as discussed for Thailand above). The feasibility and affordability of these strategies are not known exactly, but certainly there is potential to reduce infection rates. However, it is recognised that many of these strategies might not work without men also being informed and educated, and changing their attitudes and behaviour.

¹⁰⁶ This figure of 200,000 unsafe abortions in 1994 is significantly higher than the official number of abortions in South Africa in 1997 (29,326 abortions) and 1998 (40,568) reported by the Health Systems Trust, suggesting the data from these two data sources are not comparable.

Fourth, there is a need to improve the timing and rates of use of health services in South Africa, to move towards those recommended by the W.H.O. ANC programme. First, despite free antenatal care services, gestational age at first visit is, on average, very late in South Africa, with 70% of people of African origin reporting after 6 months of pregnancy (from a recent Household Survey of Health Inequalities in South Africa). Numbers of visits for many is well below four and home deliveries are still common. However, health service use is affected by several factors simultaneously, and the exact contribution of individual factors is not known (e.g. distance from the clinic, availability of transport, availability of 24 hour services, etc), making it difficult to identify and implement effective policy measures.

Fifth, there are numerous problems with the health services, including lack of basic resources in health centres (up to half health centres in North and Northwest Provinces had inadequate water, electricity, washing facility, and building structure (Fonn et al 1998)), poor management, low salaries and demotivated staff, and staff shortages. In many areas, 24 hour health services have been suspended due to security problems; also patients do not use them sufficiently due to transport problems getting to clinics during the night, and operational problems in the clinics (Ramdas et al 1996). Clearly the potential of the W.H.O. ANC programme to improve health outcomes is reduced unless these problems are addressed.

In conclusion, the discussion above has highlighted several important issues to consider when predicting the costs of the W.H.O. ANC programme in South Africa. Therefore, in using the results of the cost study and cost prediction exercise, it should be recognised not only that several issues with cost implications need to be considered, but also that the sampled health facilities do not reflect all health care settings, nor the health service use rates reflect the entire population of South Africa.

10.4.4 Implications for other countries

The cost implications of the new ANC programme for other developing countries is a key question that this thesis raises, and several issues relating to this question are discussed below. One question concerns whether costs are likely to be similar to the countries of this study. This depends on which other countries are being considered. Caution was recommended in Chapter 10 in using average trial data on health service

use and unit costs to predict the costs of the W.H.O. programme in lower-income countries, due to differences in key cost variables. Trial countries were chosen for the principal reasons that (a) there was a minimum level of antenatal care in place to act as the comparison group, (b) appropriate care could be provided when women are identified as needing inpatient care or caesarean section, and (c) there existed an infrastructure (researchers, facilities and data systems) for high quality research. Therefore, not only did these criteria exclude most low-income countries from participating, but they also reduce the applicability of the trial results to these countries, as they are likely to have different resource use, resource price, and morbidity levels.

While a detailed assessment of the generalisability of the cost or cost-effectiveness results to low-income countries was not within the scope of this thesis, the case study in South Africa gave some indication of issues that must be addressed in predicting cost impact in non-trial countries. It is likely that unit costs will vary between study countries and lower income countries, although unit costs are not necessarily lower in low-income countries¹⁰⁷. The impact on average costs of the W.H.O programme is unclear without knowledge about the resource availability and efficiency levels of specific health facilities. Also, it is not known whether the adoption of the W.H.O programme would change efficiency levels through affecting staff motivation or returns to the variable factor through higher uptake of health services. Average costs would be expected to be lower in low-income countries, due to lower wage rates as well as lower drug and equipment costs for goods manufactured in the local economy (valued in US\$ using nominal exchange rates). However, without a detailed break down of the resource use, prices and content of ANC, the impact of the W.H.O. programme on average costs cannot be predicted. Also, access to services may be much lower in low-income countries, thus reducing health service use, especially caesarean section and neonatal admission. This should be balanced with possibly more ANC visits received at the home of the patient, provided by traditional birth attendants or midwives. However, other African countries may be faced with a different set of policy issues or different levels of

¹⁰⁷ For example, an outpatient antenatal care visit in 1998 prices was found to cost between US\$1.56 and US\$4.30 in Uganda (Levin et al 1999), US\$6.01 in Ecuador (US\$3.35 in 1996 adjusted by two years of the average annual inflation rate of 34%), and US\$14.9 in Mexico (US\$7.19 in 1994 adjusted by the average annual inflation rate of 19.9%). In The Gambia average costs varied between US\$11.37 and US\$27.5 (US\$8.3 and US\$20.1 in 1991 adjusted by an average annual inflation rate of 4.6%). It should

priority to those issues discussed for study countries, and therefore careful local interpretation of the W.H.O. antenatal care programme impact is required.

A second key question relates to whether the same results concerning cost prediction methods would be found in other developing countries. As discussed above, unit costs and health service use rates are likely to differ, therefore direct and adjusted transfer methods are unlikely to be accurate. Regression analysis is also very unlikely to yield accurate predictions, especially for countries with different health service use and morbidity rates. Therefore, some form of the incremental cost impact method would need to be applied to give the most reliable, although not necessarily accurate, cost predictions. As previously mentioned, highly detailed data are needed to make an assessment of the expected impact on average costs, morbidity, referral rates and health service use. Therefore, in the absence of these data, rates will need to be assumed, from consultation with experts where possible, although efforts should be made to collect reliable data and not rely on assumptions or unreliable data. One important finding presented earlier that international agencies should note is that GNP per capita (at either nominal exchange rates or PPP) does not reflect the mean ACPP well¹⁰⁸. This contradicts some views expressed in the literature, that cost magnitude is largely related to GNP per capita (Tinker and Koblinsky 1992, Barnum and Kutzin 1993). In this respect, Murray et al (2000) appear to support the view that broad generalisations should not be made based on one indicator such as GNP per capita, stating that countries should be grouped for estimating costs based also on region, public/private splits in health care financing and provision, and burden of disease. The conclusions of this thesis would support the Murray et al view, and in the context of public health facilities the cost prediction results in this thesis can potentially contribute to future work on grouping health facilities and countries.

A third key question concerns whether the W.H.O. guidelines are affordable in lower-income countries, and raises the point that alternative models of service provision may

be recognised, in interpreting 1998 cost figures, that the average annual inflation rate used to adjust prices before 1998 may not reflect the inflation rate of health services.

¹⁰⁸ Not only was Cuba found to have a high cost per pregnancy compared to its' relatively low GNP per capita, but also Thailand had a relatively low cost per pregnancy compared to South Africa despite similar GNP per capita levels. However, note that these cross-country comparisons are based on the exchange rates underlying them.

need to be considered, as suggested for Safe Motherhood programmes (Koblinsky et al 1998)¹⁰⁹. Therefore, alternative ways of providing care must be sought, not only to make the minimum package more affordable, but to be relevant for local systems in terms of practice patterns and staff availability. For example, the infrastructure may not currently exist for all women to deliver their babies in secondary hospitals, and attendance by midwives or traditional birth attendants at home deliveries may be more appropriate. Therefore, cost predictions should be made based on separate consideration of unit costs and health service use, and thus provide justification for the decision on whether costs can or cannot be transferred.

A fourth key question concerns what other implementation issues affect the generalisability of the results from Cuba and Thailand to low-income countries. First, high gestational age at first visit and inaccessible services means that the four-visit minimum will not be achieved for many women. In the light of this, a rethinking of the recommended location, timing and contents of each antenatal visit is needed. For example, mobile clinics may be a viable although possibly expensive alternative (Fox-Rushby and Foord 1996). Second, rates of CS and inpatient admission are currently very low in most African countries, although rates vary by region and rural/urban location. Recently the international community has focussed on essential obstetric care (EOC), with the implication that the rates observed in W.H.O. trial countries are not expected to occur, or even desirable, in lower-income settings (Koblinsky et al 1999). The EOC approach reflects more the difficulties faced by most developing countries, as opposed to reflecting best practice. The implication of the EOC approach where routine care is minimal is that most pregnant women will have minimal or zero health service cost (if they have a home delivery), but a minority will have high health service cost (inpatient stay and hospital delivery), thus leading to different cost distributions to those found in this study. Third, the realizable impact on health outcome will not be achieved without compliance with quality standards, but this will impact unit costs¹¹⁰. Fourth, in addition

¹⁰⁹ The expectation of the unaffordability of the W.H.O. programme is supported by evidence from Uganda, where cost per capita of the W.H.O. Mother-Baby package was compared with the costs of current care, and it was found that spending would have to increase by about 3 times US\$1.80 per capita per year to provide care according to the W.H.O. Mother-Baby package recommendations (Weissman et al 1999).

¹¹⁰ One previous study, Ogunbekun et al (1996) assessed the feasibility and cost of improvements in the quality of reproductive health services through the Bamako initiative in Nigeria. Current practice and guidelines were compared to assess cost implications, and investment required, and prioritisation was

to estimating the likely incremental cost of the W.H.O programme, estimates would be needed of the required investments and time periods for implementing the new programme, due to the constraints imposed by annual budgets for maternity care spending. Also, the feasibility of changing the clinic operations also needs to be considered, such as the opening hours, appointment system, and patient card system, before policy is made, and whether changes fit in with other health policy aims.

In conclusion, to allow calculation of cost-effectiveness ratios for ANC and delivery care, more research on alternative means of providing care (with economic components) will be necessary in low-income countries. Due to the cost variation shown in this thesis, these trials should be both multicentre and multinational, with provisions to examine heterogeneity between centres. This viewpoint supports the Willke et al (1998) finding of large differences between country in case cost, and goes some way to answering the question raised by Johnston et al (1999) over whether cost data need to be collected in all centres in a multinational trial. In addition to clinical trial research, more research is needed to understand determinants of cost (as a first step) and to predict costs in specific settings, as well as at the generalised country or regional level suggested by Murray et al (2000) (as a next step). While some variables were concluded to explain cost variation, there was also unexplained variation which needs further examination. This will allow further conclusions about the causes of cost behaviour in different settings and for different health interventions, and therefore suggest to policy makers the likely cost variability in clinical protocols (such as those published by the W.H.O.) implemented in different settings. In order to improve the accuracy of cost predictions, key components (prices, resource use, and health service use), cost profiles, and cost determinants (economies of scale, efficiency, occupancy, case-mix, referral rate, hospital level) should be collected and reported routinely.

made of the most critical items to make the initiative work. Quality improvements involved increased unit costs, for example, of up to 40% for delivery care.

11 CONCLUSION

11.1 Summary of thesis

The aims of this thesis were to identify and test alternative methods for analysing and predicting health care costs, to construct a framework for guiding analysts in predicting costs, and to identify future areas of research in this area. A related aim of this thesis was to understand why cost generalisations between health care settings might be inaccurate. With the thesis aims and context in mind, objectives for the literature review and data analysis were chosen in Chapter 1. The objectives of the literature review were to critically review the current literature on: the contribution of economic theory to understanding health care costs; the methods of cost analysis for understanding cost determinants and explaining cost variations; the empirical evidence for factors explaining cost variations; and to identify alternative cost prediction approaches. The literature review chapters therefore served to build frameworks for analysing and predicting health care costs for use in the thesis, and to provide a context within which to interpret the results.

The objectives of the data analysis were to: estimate health care costs associated with pregnancy and childbirth in study settings; understand cost determinants and behaviour; evaluate the robustness and generalisability of costs; and test alternative methods of predicting costs. Using the results of these data analyses, a series of issues to consider when making cost predictions were discussed, and recommendations for researchers and policy makers drawn up. How this thesis achieved these literature review and data analysis objectives is described below.

Chapters 2 to 4 reviewed the literature. Chapter 2 summarised the production and cost functions underlying health care processes, defined different aspects of efficiency and outlined the economic relationships driving health care production and costs. The implications for cost behaviour and interpretation under breakdown of neoclassical assumptions were examined. Several factors were found that may cause unit costs to be different to what they would be under perfect competition: the presence of X-inefficiency in public sector organisations, economies of scale, the lack of perfect information, and barriers to closure of public hospitals or demand uncertainty leading to

over-capacity. Also, variations in resource prices, case-mix, input mix and quality of care were concluded to be likely causes of unit cost variations between health care providers.

Chapter 3 reviewed cost analysis methods used in the health care literature. Several studies were found that reviewed alternative cost analysis approaches. Theoretical foundations and methodological developments were generally more developed for statistical methods (regression analysis and data envelopment analysis) than for accounting methods. In order to provide a framework of cost analysis using accounting methods, several approaches were distinguished from the literature: cross-setting data substitution; cost profiles; efficiency scores; 2-way relationships; and output profiles. The advantage of statistical methods over accounting methods was that statistical methods take into account the impact on unit cost of several variables simultaneously. However, statistical methods required more data points (many time periods or many health facilities) compared to accounting methods. In general, all methods required cost data to be disaggregated to allow an understanding of costs. The chapter concluded that the cost analysis methods identified are generally complementary, as they can be used in combination to understand cost behaviour more fully.

Chapter 4 critically evaluated empirical evidence on several factors hypothesised to determine cost identified in Chapter 2. The review found few studies that comprehensively evaluated all factors hypothesised to cause cost variations, or that used the full range of cost analysis methods, although many examined various factors in isolation. Two main components of cost of particular relevance for the thesis were distinguished (together contributing to total cost): health service use and unit costs. Determinants of health service use were divided into patient factors and provider factors, and the empirical evidence from the developing country maternity care literature was reviewed. Although few studies made conclusions about the exact impact of each factor on health service use, some impact was identified using quantitative methods. Determinants of unit cost were also examined. Again, few studies drew exact links between each factor and unit cost, and the evidence was mixed for many of the factors (such as economies of scale) or insufficient to make conclusions (such as quality of care). Measurement problems of some factors was discussed (such as for X-inefficiency,

economies of scale, case-mix and quality of care). Therefore, this chapter provided a valuable basis from which to plan which factors to focus on, and how to interpret the results. The review on causes of cost variation and analysis methods helped identify alternative ways to make cost predictions, and these were described with examples from the literature.

Chapter 5 presented the empirical context of the thesis, empirical objectives, data requirements, data sources and data analysis methods. The main data source for the thesis were the clinical and economic components of the W.H.O. antenatal care trial, which was conducted in settings in four middle-income countries. Two of these, Cuba and Thailand, as well as a non-trial country South Africa, were the focus of this thesis. First the methods of data collection alongside the trial were described (with reference to publications from the trial), followed by a description of the sensitivity analysis, and finally the methods of data analysis. The cost analysis framework was described as consisting of cost comparisons at four 'levels' relevant to the study settings: between groups of woman based on case-mix; between health facilities; between trial arms; and between countries. Costs comparisons were described and justified in non-monetary (resource use and health service use) and monetary (unit costs and cost per pregnancy) units. Data analysis methods include identifying statistically significant cost variations, examining causes of cost variation, and finally predicting costs using alternative cost prediction methods.

In the recognition that cost analysis in non-monetary units can provide useful understanding of costs before valued in monetary units, Chapter 6 presented and analysed health service use and resource use data. Significant variation was found between individual health facilities in both health service use and resource use, thus suggesting that the trial arm a woman receives care in is not the major predictor of cost. The analysis found that there were multiple determinants of health service use, including patient costs, case-mix and practice style. The analysis of resource use was found to be valuable in providing information about the main cost drivers and the requirements for health care, and some inter-health facility differences were found in staff productivity, drug use, equipment lists, and building space.

Chapter 7 presented and analysed unit cost variation to understand causes of unit cost variations. Health facilities were found to vary significantly in terms of resource use quantity as indicated by staffing ratios, technical efficiency scores (from DEA), input mix, and scatter plots (for economies of scale). The results showed that staffing patterns were the main determinant of average cost, due to the high proportion of cost accounted for by salaries. Variations in staffing patterns were concluded to be more related to non-patient factors within country (which includes variation in management practice), than patient (case-mix) differences. Drug costs as a proportion of unit cost were found to vary within and between countries (due partly to case-mix differences). Prices were also different between countries, but were found not to explain much or any of the unit cost differences. Differences in uncertainty between country also changed the cross-country unit cost variations under certain assumptions, especially alternative values for the opportunity cost of staff, and the conversion factor to present costs in US\$. Finally, some aspects were not examined in sufficient detail to allow conclusions, including the impact of quality of care differences on unit costs, and the presence of economies of scope. In conclusion, the large differences within and between countries in unit costs are a warning that unit costs cannot easily be generalised, at least not without making adjustments for known differences between settings.

Chapter 8 combined the results of previous chapters to understand variations in cost per pregnancy and also presented the results of new cost analyses. The large inter-setting variations in unit costs and health service use both contributed to large variations in cost per pregnancy, both within and between countries. Also, the results of the 2-way comparisons and regression analysis contributed to an understanding of the factors or variables most likely to influence average cost per pregnancy. Health service use differences were largely responsible for the cost per pregnancy variations in all countries, especially caesarean section and neonatal admission. Also, some risk factors and events during pregnancy, delivery and postpartum were significant predictors of cost. While some of these were significant in all three countries, the percentage impact on cost was different (due to different unit costs) thus suggesting non-generalisability of coefficients across countries. The large variability in cost per pregnancy between health facilities suggests that in predicting cost it is important to identify whether a health

facility is a high, mid or low cost provider, and which ANC programme is being providing.

Chapter 9 tested a range of cost prediction methods, and compared the cost predictions with observed costs. While all the cost prediction methods gave some accurate results (especially cost transfer between Cuba and South Africa), the incremental cost impact method was found to be the most reliable in that cost per pregnancy and incremental costs were accurate in both countries. The adjusted transfer method was found to work between countries with similar unit cost and health service use levels, and where adjustments could be made for identified differences. Cost prediction using regression models gave predicted cost less than observed cost in all countries, and cross-country predictions gave similar results to the direct transfer method. As the incremental cost impact method was concluded to be the most reliable cost prediction method, it was used as the base case in South Africa, where a small cost increase was predicted under the W.H.O. programme (although the range of predicted cost covered zero). Due to larger cost impacts, the incremental cost impact method was thought to be less reliable in lower-income countries, as there would be wider ranges on the mean values due to greater uncertainty about the cost and health status impact of the W.H.O. programme.

Finally, Chapter 10 discussed issues relevant to cost prediction. First, several choices that must be made by the analyst in predicting costs were clarified. For example, the analyst must define the type of cost required, the data sources, and the relevant measure of central tendency. Also, how resources are valued nationally and internationally is critical to the accuracy of the cost prediction, and the interpretation of the results. Second, as the definitions of accuracy and economic significance were central to judging the success of cost prediction methods, these definitions were critically evaluated and alternative ones proposed. For this reason, it was recommended not to judge a cost prediction method based on a single criterion, but instead using a range of measures, and determinants of performance. Third, the role and limitations of cost analysis was discussed, in terms of both the shortcomings of the analytic options to analyse costs, and why some cost variation remained unexplained. The limitations of cross-country cost analyses were discussed. In particular, currency conversion, the use of a static framework and cross-country heterogeneity of inputs and outputs were cited

as reasons why cost differences should be interpreted with caution. Finally, issues for policy makers to consider when generating and using cost prediction results in planning maternity services were discussed, and included the direction of impact on health outcomes, and changes required to the health system to implement the programme. The cost results were discussed in the context of current antenatal care policy issues in the study countries. Not only was cost variability mentioned as a cause for caution when predicting costs, but also the possibly increased inaccuracy when predicting costs in lower-resourced settings, where unit costs, health service use, and cost determinants are likely to be different to study countries, and also there exist some constraints to implementing the W.H.O. ANC programme in its' original form.

11.2 Thesis conclusions

To date, few studies have taken a comprehensive approach to analysing and predicting costs, which is part of the reason why cost generalisability has not been explored in the depth that it deserves. The conclusions of this thesis cover empirical, methodological and policy issues, and are aimed at both researchers in terms of the methodology and focus of future research, and policy makers in terms of implications for resource allocation.

Empirical conclusions

- ❑ *Magnitude of unit costs.* The most expensive type of maternity care (per health service use) in all countries was caesarean section, followed by neonatal intensive care (per day) in Cuba, and vaginal delivery in South Africa and Thailand. However, the hospital stay following caesarean section in Cuba and South Africa (ALOS = 7 days) was more costly than CS itself.
- ❑ *Profiles of unit costs.* Staff costs were consistently the highest resource contributor to unit cost in all countries and for all types of care (>58%), except CS in Thailand (29% average). Drug costs were also a significant resource contributor for outpatient ANC in Cuba (38% average). Technical support (all support departments providing direct services to health care departments except laboratory) contributed towards 13-30% of unit costs in Cuba and Thailand and <10% in South Africa, followed by administration costs (4-8% in all countries). Laboratory costs contributed towards 4-

13% of unit costs in all outpatient departments, except 47% in America Arias hospital in Cuba.

- ❑ *Profiles of cost per pregnancy.* Antenatal care consistently took less than 42% of cost per pregnancy in all settings (as low as 17% in South Africa), leaving the rest to inpatient care during pregnancy (up to 19% in Cuba), delivery care (up to 38% in South Africa), postpartum care (up to 19% in Thailand), and neonatal care (up to 22% in Cuba).
- ❑ *Variability in cost per pregnancy.* Costs varied significantly between randomised health facilities both within and between countries. For example, cost per pregnancy within the intervention arm polyclinics in Cuba ranged from US\$298 to US\$504. Between countries, cost per pregnancy in the intervention arm ranged from US\$86 in Thailand to US\$402 in Cuba, at nominal exchange rates (at purchasing power parity the costs were US\$167 and US\$989, respectively). Cost per pregnancy was positively skewed in all health facilities and countries.
- ❑ *Impact of uncertainty.* Unit costs were found to be relatively robust to most sources of uncertainty, except valuation of staff cost, and the currency conversion method. Threshold analysis showed that only minor reductions in health service use in the intervention arm in Cuba would have been necessary to generate a result of significant difference between trial arms (a 1% lower CS rate or 0.2 antenatal visits less per woman in the intervention arm).
- ❑ *Causes of unit cost variation.* A multitude of factors was found to be responsible for unit cost variations between settings. Unit cost variations reduced when staff productivity and occupancy rates were standardised in all health facilities within country. Also, economies of scale were suspected in Cuba, but evidence was weaker for Thailand. Between countries, price differences were not found to be the main cause of cost variation.
- ❑ *Causes of cost per pregnancy variation.* Both unit cost and health service use variations were responsible for cost per pregnancy variations. Regression analysis found several characteristics of patients that determined cost per pregnancy, although there was limited consistency in significant predictors between countries.
- ❑ *Cost per pregnancy prediction.* Most of the cost prediction methods gave accurate predictions between Cuba and South Africa, due to the similarities in unit costs and health service use between these two countries. However, cost predictions using

transferred data were generally inaccurate in Thailand. The only method that was consistently accurate for all countries was the incremental cost impact method.

Methodological conclusions

- ❑ *Cost inclusion.* When comparing, predicting, or generalising costs between settings, it should be made clear which costs are included and why, and how this compares with current economic evaluation standards (such as the reference case).
- ❑ *Cost presentation.* Cost presentation and tabulation are important in understanding cost determinants before more complex analyses are undertaken. Therefore, for both those conducting economic evaluations alongside clinical trials and those predicting costs using trial data, it is important to distinguish between unit costs and health service use. Also, confidence intervals and measures of central tendency provide useful additional information.
- ❑ *Cost measurement.* Cost measurement alongside a randomised clinical trial was found to have some disadvantages (such as constraints to collecting unit costs on individual patients due to interfering with health care), but these were thought to be outweighed by the advantages, the main one of which was the availability of data from the trial data forms on health service use per patient.
- ❑ *Cost robustness.* Uncertainty in some key areas was shown to influence costs significantly, and therefore a detailed sensitivity analysis should be done and the results consulted before costs data are generalised or conclusions made about predictive accuracy.
- ❑ *Cost analysis.* A range of cost analysis methods should be used when trying to understand cost behaviour. If statistical methods are used, the results should be interpreted in the light of the findings of cost analysis using cost profiles and sensitivity analysis. However, the range of options for cost analysis is highly dependent on the data sets available. Also, there exist constraints in measuring some relationships in the health sector predicted by economic theory. This is due to data deficiencies, measurement error, and constraints in cross-country cost analysis.
- ❑ *Cost prediction.* The more reliable forms of cost prediction can only be undertaken when data are available to examine or model differences between settings (adjusted transfer method), to assess the likely cost impact (when using the incremental cost impact approach), or to conduct a regression analysis. Conclusions about the

performance of the cost prediction methods depended critically on how 'accuracy' and 'economic significance' are defined.

- ❑ *Currency conversion.* Both national and international policy makers should be careful not to generalise resource price or unit cost data across borders without taking into account differences in price levels between countries, which is partially if not totally taken into account in the purchasing power parity measure.
- ❑ A set of prescriptive guidelines for making cost predictions cannot be drawn up until further work has been conducted to test other cost prediction methods and compare findings with this study. However, the choice of cost prediction method is highly dependent on which type of cost is being predicted, the relative importance of the cost prediction, the data and skills available, and the funding available.

Policy conclusions

- ❑ *Cost contributors.* In view of the main contributors to cost, measures for improving efficiency should be aimed at improving the use of contributors to unit cost (staff, drugs) and case cost (reducing unnecessary CS, inpatient admissions, or antenatal visits).
- ❑ *Implications of cost variation.* Unit costs are higher in many health facilities than they would have been if resources were used efficiently (e.g. from the results of the data envelopment analysis). Unit costs variations are likely to be reduced if health services are planned so that staff productivity and occupancy rates are standardised between health facilities. Also, case cost variation could be reduced by standardising medical practice ('practice style').
- ❑ *Implications for Cuba.* The findings suggest that the antenatal care programme could be implemented nation-wide with no major changes, although the reduction in antenatal visits towards the recommended may not be immediate. Other forms of care, such as home visits, ultrasound, and maternity homes, can operate alongside the ANC programme. Due to the almost unique character of Cuban health services, and its' isolation from the world currency markets, it is not advisable to generalise cost data from other countries. However, within country health care costs are not likely to vary substantially outside those observed in those health facilities studied, due to the standardised structure of health services throughout Cuba.

- ❑ *Implications for Thailand.* Similarly, the findings suggest that the antenatal care programme could be implemented nation-wide with no major changes, although in settings where there are less staff there may be time constraints to provide the programme. Again, it is not advisable to generalise cost data from other countries, unless it can be proved that prices and health service use rates are similar. Within country, due to the variation in unit costs and cost per pregnancy found between hospitals, and the variation in resource availability between regions, it is advisable to identify hospitals according to whether they are low, mean or high cost providers.
- ❑ *Implications for South Africa.* It is unclear how easily the ANC programme would be adopted in South Africa, due to the extra staff that may be required to give women additional time during outpatient visits. However, the staff skills and referral systems exist in the setting of the study for implementation of the ANC programme.
- ❑ *Implications for other countries.* In lower-resourced settings, where variations between current care and the W.H.O. ANC programme are even greater than study countries, cost per pregnancy predictions should be based on local data, such as levels of efficiency, staff productivity, impact on morbidity, accessibility, patient and provider compliance, carrying capacity of the health system, prices, and the availability of operative delivery and neonatal intensive care facilities.
- ❑ *Requirements for further research.* Policy makers at the international level should support the further development and validation of cost prediction methods. Investment into research in these issues in the short-run to improve methods will save resources in the longer run from the use of inaccurate cost data in decision making.

11.3 Recommendations and agenda for research

Although this thesis has highlighted a range of issues in the field of health economics that require further discussion and agreement, the most important recommendations for researchers and policy makers listed below include those of: measuring and reporting cost data routinely, in clinical trials, and in multi-country trials; applying cost analysis methods; making international comparisons; using and judging cost prediction methods; and defining economic importance.

Measuring and reporting cost data in clinical trials

Researchers should consider generalisability issues in the design of costing studies. The following recommendations are already part of current economic evaluation guidelines (Weinstein et al 1996, Drummond et al 1996): clearly define and justify the study boundary; collect patient level data on health service use and unit costs, if possible; measure opportunity cost; present confidence intervals; and quantify uncertainty using sensitivity analysis. These recommendations are concerned with the measurement, presentation and robustness of the data. In addition, several further recommendations are made for researchers for better understanding of the data (some of which are also recommended in current economic evaluation guidelines): report cost components separately, by price, resource use and health service use; report skewed cost data using mean, median, mode, and confidence intervals; report important determinants of cost, such as staff productivity and case-mix; and identify opportunity cost when it diverges from market prices. When reporting cost results in a different currency, researchers should state and justify the currency conversion method based on the aims of the study (whether for international comparison or health care planning purposes), and interpret the cost results for the reader who may not be familiar with the context of the study.

Finally, when a trial runs over a time period of several months or years, it must be decided which period the cost data refer to, and how many months of unit costs are collected. The year or month for which cost data are reported depends on which is the most useful for policy making, and when the data collection period is (it may be at the start or the end of the trial, and therefore not reflect the whole trial period). The choice of number of months¹¹¹ that unit cost data refer to depends on whether throughput and expenditure are seasonal variables. If they are, then some idea of the variation of unit cost over the year is needed, to approximate the average. Experience has shown that research costs of collecting additional months of data decline after the first month is collected, due to familiarity with staff providing the information, and the fact that staff and equipment lists are already drawn up and only monitoring of month to month changes is needed. It is therefore recommended that more than a single month is collected, to see whether variability exists. If variability does exist, the number of months required depends on the extent of variability. If just a few months of data are

collected, these can be supplemented with aggregate monthly expenditure and throughput patterns for a whole year to check whether they are related to season.

Measuring and reporting cost data in multi-country trials

While the above recommendations apply to cost studies alongside clinical trials generally, special recommendations are necessary for data collected and reported alongside multi-country trials, where additional decisions are needed concerning sampling methodologies. First, how many countries should be included? Current cost and economic evaluation guidelines are not clear about how to choose sample size. Few previous multi-country trials have measured costs in all countries, but they have shown cross-country variation, thus suggesting evidence is required to justify not collecting cost data in some countries. The findings of this study suggest that cross-country variability is sufficient to justify reporting of primary cost data for all countries in the study. Second, how many health facilities should cost data be collected in, in each country (assuming there is more than one per country)? There may exist cross-facility unit and/or case cost variation, and again, evidence is required to justify not collecting cost data in some facilities. For both these questions, two viewpoints should be considered – the scientific and the practical. The first, the scientific viewpoint, asks what sample size is necessary to prove whether or not a difference exists between the treatment options. This must naturally take account of what variation exists between health facilities. If prices, efficiency, health service use, etc, are similar between health facilities, then it may not be necessary to collect data in all of them. Also, when it is not known what facility-by-facility variation exists, either a pilot study should be conducted if time allows to make a more informed decision, or the sample size chosen should err on the cautious side. The findings of this study were that inter-health facility variation was significant, and omission of one health facility from each trial arm may have changed the results (if a high cost facility from one arm, and a low cost facility from the other arm). However, objective criteria are needed for judging what level of variation is large enough to warrant collecting data from all health facilities in a multicentre study.

The second, the pragmatic viewpoint, asks what resources have been made available to the economic study, and tries to make the best use of those resources – first identifying

¹¹¹ Months were chosen in the antenatal care trial as it reflected the accounting period for costs and

the availability and quality of data from routine sources, and second identifying low cost but reliable means of filling data gaps. The clinical trial may be able to provide important data on health service use, as was the case in the antenatal care trial. Where significant additional cost data collection or data compilation efforts are required, a trade-off must necessarily be made between the number of countries, health facilities and months of data collection that can be included, and the final decision about sample sizes of each will depend on where the greatest variability exists, if known (greater variability requires greater sample size). The analyst must bear in mind that the sample size should be sufficient to answer the study question. Where countries are known to be heterogeneous, it would seem safest to first ensure that a minimum cost data set is available for each country (one month and one health facility). If research funds are available to collect more than this minimum cost data set, then health facility sample size should be judged based on known causes of variation, which include size (economies of scale), occupancy (returns to the variable factor), case-mix, 'level' of health facility, and staff mix. Other characteristics not examined in this study that distinguish hospitals should also be taken into account (from the findings of the review in Chapter 4), such as rural/urban location, with/without emergency department, whether or not a teaching hospital, and any other factors that may alter unit costs.

Measuring and reporting cost data in routine data systems

While research as outlined above is important, it tends to be one-off, and therefore does not provide decision makers with continuous and up-to-date monitoring of how key economic data change as health systems change. Also, the greater the investment in routine data systems, the easier and cheaper it is to do research. Such routine data systems will be useful in assessing the appropriateness of cost transfers from other settings, and in making appropriate adjustments.

Recommendations for routine data collection at the national level include: price lists for each type of resource (personnel, equipment, drugs, materials); equipment plan for different types of health facility; staffing plan for different types of health facility; numbers of staff at national, regional and district level; population size and population reporting rates by region and district; and health facility and staff coverage rates (per

100,000 population). It is better if actual data are available on equipment and staff lists, as opposed to just the plans. Some of these data will be aggregations of data collected and reported routinely by health facilities, and would most likely be done once a year. Countries can be compared using these data and, with other macro-economic data, allow conclusions about whether data transfer will be highly inaccurate from another country.

Recommendations for routine data collection at the health facility level (minimum list) include: equipment lists and differences with 'plan', staff lists and differences with 'plan', throughput (by category) per department, staff productivity, health care provision schedules; occupancy rates; average length of inpatient stay. These data should be updated on a monthly basis, when available. These data allow a comparison across health facilities for a crude assessment of whether unit costs can be transferred within country and crude cost analyses (when transferring data from outside the country, some of the national level data will also be needed).

An advanced list of recommendations for routine data collection at the health facility level include, in addition to the minimum list: unit costs for important procedures, measures of case-mix, average length of inpatient stay by patient/disease type, measures of quality of care and patient satisfaction. However, how case-mix, quality of care and patient satisfaction are measured will need to be defined in order for collection to be standardised, and therefore comparable across settings. These data allow a comparison across health facilities for a more refined assessment of whether cost findings from other settings can be transferred within country. These data will also help for: budgeting purposes, deciding which services to provide, refined cost analyses, where and how to improve efficiency, and what investments are required. While routine collection and reporting is recommended for these data, this may not be necessary or feasible for some variables, and well-conducted periodic research studies may be conducted instead to provide such data.

Cost analysis to understand cost determinants and cost variations

Researchers should examine cost distributions and confidence intervals instead of point estimates in comparing costs and making conclusions about cost variations. Also, to improve the understanding of unit costs, studies are needed examining the micro-level

causes of inefficiency, and assessing the impact of quality of care and case-mix on unit costs. Policy makers should pay attention to results of cost analyses that have implications for how to improve efficiency by reducing resource wastage and considering input substitution options to reduce unit costs. Also, policy makers should help implement (evidence-based) health care guidelines to reduce unit and case cost variability (especially with regard to staff policy and length of hospital stay), bearing in mind the cost-effectiveness of alternative health care delivery approaches.

International cost comparisons

International researchers need to clarify the purposes of international valuation, whether for comparison or pooling of cost data, or assessing US\$ cost to funding agencies, as this will determine the appropriate currency conversion method. In order to avoid some of the problems associated with cross-country cost comparisons, researchers should consider comparing costs internationally using non-monetary cost units. However, all types of cost comparison should bear in mind qualitative differences in health care inputs and outputs between country. Finally, policy makers should understand that cross-country cost transfers should not be made without taking account of different purchasing power, prices, resource use efficiency, and health service use differences.

Cost prediction methods

Researchers should develop a language and framework for different aspects of cost generalisability or cost prediction that allows a common understanding and increases clarity. Such a framework would force researchers to be more explicit about what they are doing and why, and also help policy makers interpret research. Also, researchers are recommended to test and compare alternative cost prediction methods in a range of settings. While the findings from this thesis have moved the debate on in terms of defining a cost prediction framework, linking it to cost analysis, and testing cost prediction methods, it is recommended that researchers seek alternative (both simple and complex) cost prediction methods, and further test and compare cost prediction methods between studies. Also, costs should be predicted using different measures of central tendency and confidence intervals or ranges, as well as marginal and average costs. In order to help judgement about cost prediction methods, measures of 'accuracy' and definitions of what constitutes 'acceptable' inaccuracy should be agreed. Finally,

policy makers should examine the cost implications of implementing a reduced-form W.H.O. ANC programme in lower-resourced settings, and the resulting implications for accuracy of cost transfer methods. Policy makers should also be open to collaboration with researchers to predict costs using the incremental cost impact method, using costing spreadsheets such as the one developed by the W.H.O. for the Mother-Baby package (Weissman et al 1999).

Economic importance

Researchers are recommended to develop further a working definition of economic significance, taking into account the viewpoints of both statisticians and policy makers, and conduct research into whether a widely applicable working definition is possible. Also, further research is needed into whether different definitions of economic significance are appropriate when predicting different types of cost (e.g. unit cost, cost per pregnancy, incremental cost) and in different settings. Policy makers will play a key role in determining what costs changes are economically significant.

In conclusion, this thesis has demonstrated that considerable thought needs to go into cost prediction when inadequate primary data are available for estimating costs. Cost data transfers (generalisation) have been shown to be unreliable in terms of accuracy for both within and between country cost predictions. An incremental cost impact approach to cost prediction, although it requires more detailed health service and patient data, was shown to be more reliable, as it takes into account local impacts on prices, resource use and health service use. Therefore, researchers and policy makers are encouraged to work together in improving routine reporting of cost and epidemiological data to improve the accuracy of costs when prediction is necessary, and separate reporting of resource use, prices, and health service use. A working party is therefore recommended to discuss in greater depth the issues raised in this study surrounding cost prediction and cost generalisation, and to build consensus amongst both researchers and policy makers.

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APPENDICES 1-16

Appendix 1: Summary of cost analysis literature

Table 1.1: Regression analyses with total costs as the dependent variable

Author(s), year	Data set and country	Causes of cost variation
Cohen (1970)	25 hospitals in USA	1. Teaching hospitals have a larger optimum size 2. Quality influences the optimum size
Francisco (1970)	4,710 hospitals in USA	1. EOS existed in small hospitals, while there was CRS in large hospitals
Baron (1978)	803 hospitals in UK	1. EOS existed in large units of hospitals 2. Quality increased with the size of the hospital
Pauly (1978)	50 hospitals in USA	1. Input prices explained 6% of unit cost variation 2. Case-mix had a significant impact on unit cost 3. Admitting physicians increases cost marginally
Jenkins (1980)	101 hospitals in Canada	1. DOS existed, optimum size 100-300 beds
Conrad and Strauss (1983)	114 hospitals in USA	1. CRS existed
Cowling and Holtman (1983)	138 hospitals in USA	1. Economies of scope were significant
Sloan et al (1983)	367 hospitals in USA	1. Non-physician costs were higher in teaching hospitals
Chernichovsky (1986)	19 hospitals in Israel	1. Case-mix had a significant impact on unit costs 2. Inflation rates were higher in health sector
Granneman et al (1986)	1,690 hospitals in USA	1. EOS existed 2. Case-mix had a significant impact on unit costs
Frank and Taube (1987)	755 free standing mental health clinics in USA	1. DOS existed 2. Decentralisation increased efficiency 3. There was excess doctor time available
Kass (1987)	1,704 health agencies in USA	1. EOS inconclusive
Vitaliano (1987)	166 hospitals in USA	1. EOS existed
Vita (1990)	296 hospitals in USA	1. EOS inconclusive
Custer and Willke (1991)	564 hospitals in USA	1. EOS existed 2. Economies of scope were significant
Wouters (1993)	42 health centres in Nigeria	1. Staff mix had a significant impact on unit costs 2. The efficiency index did not affect unit costs 3. Quality reduces unit costs
Bitran-Dicowsky and Dunlop (1993)	15 hospitals in Ethiopia	1. CRS and small DOS exist
Zuckerman et al (1994)	4,149 hospitals in USA	1. Occupancy, size, input use intensity, and the presence of skilled workers had a significant impact on unit costs
Scott and Parkin (1995)	76 hospitals in UK	1. EOS and economies of scope were inconclusive
Csaba (1997)	>200 hospitals in UK	1. Trust status increases costs 2. Market capacity influences costs 3. Competition increases efficiency

Table key: EOS – Economies of scale; DOS – Diseconomies of scale; CRS – Constant returns to scale

Table 1.2: Regression analyses with average costs as the dependent variable

Author(s), year	Data set and country	Causes of cost variation
Carr and Feldstein (1967)	3,147 hospitals in USA	1. EOS existed until 190 beds, then DOS
Mann and Yett (1968)	Comparing 3 cost studies from USA	1. One study showed significant EOS, two studies did not
Berry (1970)	Hospitals in USA	1. Case-mix had a significant impact on unit cost
Lave and Lave (1970)	74 hospitals in USA	1. Weak evidence of EOS
Evans (1971)	185 hospitals in Canada	1. CRS and DOS existed 2. Case-mix had a significant impact on unit costs 3. Occupancy had a significant impact on unit costs
Salkever (1972)	86 hospitals in USA	1. There was a delayed impact between general inflation and health sector inflation rates
Lee and Wallace (1973)	52 hospitals in USA	1. EOS existed 2. Case-mix had a significant impact on unit costs
Lave & Leinhardt (1976)	2,449 patients in USA	1. Case-mix had a significant impact on unit costs
Feldstein and Shuttinga (1977)	55 hospitals in USA	1. Case-mix explained more than 50% of unit cost variation
Bays (1980)	41 hospitals in USA	1. CRS existed 2. Admitting physician, case-mix, and case flow had a significant impact on unit costs
Birnbaum et al (1981)	11 previous cost analyses by the authors in USA	1. Size and occupancy rate had a minimal impact on unit costs 2. Type of facility and ownership had a significant impact on unit costs
Friedman and Pauly (1981)	800 hospitals in USA	1. Low capacity use increased unit costs 2. Large size leads to higher occupancy rates 3. Case-mix had a significant impact on unit costs
Barer (1982)	87 hospitals in Canada	1. Case-mix had a significant impact on unit costs 2. Teaching had a significant impact on unit costs
Hosek and palmer (1983)	360 hospitals in USA	1. Case-mix had a significant impact on unit costs 2. Quality of care had a significant impact on unit costs
Lee and Birnbaum (1983)	671 nursing facilities in USA	1. Scale and occupancy had a minimal impact on unit costs 2. Case-mix and service-mix had a significant impact on unit costs 3. Reimbursement grouping had the most significant impact on unit costs
Schlenker et al (1983)	78 nursing homes in USA	1. Case-mix had the most significant impact on unit costs 2. Quality of care had a significant impact on unit costs
Hornbrook and Monheit (1985)	380 hospitals in USA	1. EOS existed 2. Case-mix had a significant impact on unit costs
Wan et al (1987)	23 hospitals	1. EOS existed 2. Ownership had a significant impact on unit costs 3. The optimal staff mix was 1.8 residents per dentist
Keeler (1990)	7,156 patients in USA	1. Case-mix had a significant impact on unit costs 2. Prices had a significant impact on unit costs
Dor et al (1992)	767 haemodialysis units in USA	1. DOS exist 2. Case-mix had a significant impact on unit costs
Shiell et al (1993)	123 residential facilities in USA	1. There was an n-shaped cost curve 2. Case-mix had the most significant impact on unit costs 3. Ownership had a significant impact on unit costs

Table key: EOS – Economies of scale; DOS – Diseconomies of scale; CRS – Constant returns to scale

Table 1.3: Regression analyses with case costs as the dependent variable

Author(s), year	Data set and country	Causes of cost variation
Cromwell (1987)	150,000 patients, USA	<ol style="list-style-type: none"> 1. Urban location resulted in 13% to 61% higher unit costs 2. Case severity and level of technology was higher in urban locations
Coverdale et al (1990)	1,150 hospitals, UK	<ol style="list-style-type: none"> 1. Larger hospitals has higher unit costs 2. The impact of hospital age and specialisation did not influence unit costs
Frank et al (1990)	2,802 patients, USA	<ol style="list-style-type: none"> 1. Ownership had a significant impact on unit costs 2. Health and mental status did not have a significant impact on unit costs
Knapp et al (1990)	136 patients, UK	<ol style="list-style-type: none"> 1. Case-mix had a significant impact on unit costs
Ashford (1991)	395 hospitals, UK	<ol style="list-style-type: none"> 1. Length of stay had a significant impact on unit costs 2. Specialty size had a non significant impact on unit costs 3. Diagnostic mix had a non significant impact on unit costs
Samson (1991)	70 nursing institutions, USA	<ol style="list-style-type: none"> 1. Low birth-weight had a significant impact on unit costs 2. Teaching status resulted in lower marginal costs
Beecham et al (1993)	216 patients, UK	<ol style="list-style-type: none"> 1. Case-mix had a significant impact on unit costs 2. Ownership had a significant impact on unit costs
Dudley et al (1993)	155 patients, USA	<ol style="list-style-type: none"> 1. Case-mix had a highly significant impact on unit costs
Knapp et al (1993)	140 patients, UK	<ol style="list-style-type: none"> 1. Pre-admission variables had a significant impact on unit costs 2. Low educational status resulted in higher unit costs
Voss et al (1994)	464 patients, Holland	<ol style="list-style-type: none"> 1. Case-mix had a significant impact on unit costs 2. Length of stay had a significant impact on unit costs
Butler et al (1995)	301 patients, Australia	<ol style="list-style-type: none"> 1. Case-mix had a significant impact on unit costs 2. Length of stay had a significant impact on unit costs
French et al (1995)	60 patients, UK	<ol style="list-style-type: none"> 1. Case-mix had a significant impact on unit costs 2. Length of stay had a significant impact on unit costs
Soderlund et al (1995)	12 hospitals, UK	<ol style="list-style-type: none"> 1. Case-mix had a significant impact on unit costs 2. Hospital size had a non significant impact on unit costs 3. Occupancy had a non significant impact on unit costs 4. Teaching status had a non significant impact on unit costs
Clarke et al (1996)	363 patients, UK	<ol style="list-style-type: none"> 1. Staff-patient contact time had a significant impact on unit costs 2. Length of stay had a significant impact on unit costs
Conrad (1996)	44,397 patients, USA	<ol style="list-style-type: none"> 1. Capitation payments resulted in lower unit costs 2. Clinicians given cost data resulted in lower unit costs 3. Care co-ordination mechanism being used resulted in lower unit costs
Khoshnood et al (1996)	588 patients, USA	<ol style="list-style-type: none"> 1. Case-mix had a significant impact on unit costs 2. Mechanical ventilation resulted in higher unit costs 3. Discharge status had a significant impact on unit costs 4. Insurance type had a non significant impact on unit costs
Cowper et al (1997)	92,449 patients, USA	<ol style="list-style-type: none"> 1. Case-mix had a highly significant impact on unit costs 2. Teaching hospital had higher costs and a longer LOS 3. Medicare/aid patients had lower unit costs 4. High throughput resulted in lower unit costs 5. Higher wages (wage index) resulted in higher unit costs

Table 1.4: Data envelopment analysis studies.

Authors, year	Data set	Input variables	Output variables	Efficiency results
Nunamaker (1983)	17 hospitals, USA	Inpatient routine costs.	Geriatric IPD, Paediatric IPD, Maternity IPD.	Cost per case is highly correlated to efficiency rankings (0.73 & 0.94)
Sherman (1984)	7 hospitals, USA	Non-physician FTE, Available bed days, Supply costs.	IPD (< and > age 65), Number of nurses and residents trained.	Inefficiency from overstated supply costs, excess beds & FTEs
Banker et al (1986)	114 hospitals USA	Beds, nursing services, Operating costs.	Adult IPD, paediatric IPD, geriatric IPD	RTS depends on age, 45 efficient hospitals
Grosskopf & Valdmanis (1987)	82 hospitals, USA	No. physicians, FTE non-physicians, Adm., Net plant assets.	IPD (acute, ICU), Number of surgeries, Number of OPV.	Public hospitals more efficient than private not-for-profit hospitals
Huang and McLaughlin (1989)	193 rural PHC programmes, USA	Staff FTE, Age of programme, User characteristics.	Total number of "encounters" with 3 types of staff.	Larger programmes tended to be less efficient
Valdmanis (1990)	41 hospitals, USA	Staff numbers, Capital assets	IPD (acute, ICU and surgery), OPV.	Public hospitals more efficient than NFP.
Ozcan et al (1992)	3,000 hospitals, USA	Capital, No. services, Size, Staff/supply cost.	Hospital discharges, Training FTEs, OPV.	43% of hospitals efficient (more public)
Grosskopf & Valdmanis (1993)	88 hospitals, USA	Staff numbers, Net plant assets, Case-mix index	IPDs, No. surgeries, OPVs, ICU days, emergency visits	Most hospitals are operating at ~85% efficiency
Ozcan and Luke (1993)	3,000 hospitals, USA	Capital assets, Number of non-physicians, Supply costs.	Treated cases, OPVs, Teaching FTEs	% of efficient hospitals in an area depends on local population size
Ehreth (1994)	All USA Medicare hospitals	Capital and salary costs.	Discharges (by type).	Efficiency differences explained part of cost differences.
Kooreman (1994)	292 Dutch nursing homes	Staff numbers.	Full care patients, Day care patients.	20% of nursing homes are efficient.
Bannick (1995)	284 hospitals, USA	Beds, No. services, FTE, Operating costs.	IPD (case-mix adjusted), OPV.	20% of hospitals are efficient (more small)
Luoma et al (1996)	202 health centre, Finland	Operating costs.	IPD (by type), OPV (by type).	12% of hospitals are on the efficiency frontier
Magnussen (1996)	All Norwegian hospitals	No. physicians, nurses & other labour, Beds.	IPD, OPV, Medical /surgical cases.	Efficiency depends on output specification.
Broomberg (1997)	9 hospitals, South Africa	Recurrent costs, Capital costs, (by resource + department).	IPAs, IPDs, OPVs, Number of operations (annual).	Results sensitive to inputs and outputs, and which model used.
Gordon et al (1997)	All Scottish hospitals	Beds, Nursing/medical staff costs, Other costs.	Inpatient cases.	Results sensitive to inputs and outputs.
Giuffrida and Gravelle (1997)	90 health agencies in UK	Gross expenditure, Quality indicators, SMR	GP practices and output targets met	50% of agencies are on the efficiency frontier, profit & NFP av. 67%.
Rosenman et al (1997)	28 HMOs in USA	Capital assets, Operating expenses	Number of members in health plan	Large HMOs are the most efficient
Bates et al (1998)	107 general practices in UK	Staff, medicine, capital and rental costs.	Size of GP practice list, by type of patient	Efficiency depended on output measure chosen, 7 were efficient.
Puig-Junoy (1998)	16 ICUs in Spain (993 patients)	6 types of labour input.	Patients treated, Mortality risk, Status at discharge.	15.4% of patients were managed efficiently.

Table key: IPD – Inpatient day; IPA – Inpatient admission; OPV – Outpatient visit; FTE – Full-time equivalent staff; ICU – Intensive care unit; HMO – Health maintenance organization; PHC – Primary health care; NFP – Not-for-profit; GP – General practitioner; SMR – Standardised mortality rate

Table 1.5: Characteristics of regression analysis and data envelopment analysis

Characteristic	Regression analysis	DEA
Assumptions about production/cost frontier	Strong	None
Test assumptions about frontier	Yes	No
Assumptions about error distributions	Strong	None
Test distributional assumptions	Yes	No
Test for inclusion of variables	Yes	No
Distinguish random factors from efficiency variations	Yes	No
Allow for environmental factors	Yes	Yes
Allow for multiple outputs/ multiple inputs	Only if canonical regression	Yes
Problems if multicollinearity	Yes	No
Provide information on "peer" organisations	No	Yes
Vulnerable to small number of observations	Yes	Moderately
Vulnerable to endogeneity bias	Yes	Yes
Test for endogeneity bias	Yes	No

(Source: Giuffrida and Gravelle 1999)

Table 1.6: Findings of the literature on patient factors affecting health service use

Factor	Study	Country	Care type*
Geographical accessibility	Voorhoeve et al (1984)	Kenya	DEL
	Materia et al (1993)	Kenya	MAT
	Dujardin et al (1995)	Zaire	DEL
	Swain et al (1992)	India	ANC
	Rasmussen (1990)	Guatemala, Indonesia	ANC
	Abbas et al (1986)	Jordan	MAT
	Ossis et al (1993)	Brazil	ANC
	Hamilton et al (1987)	South Africa	ANC
	Fantahun et al (1995)	Ethiopia	ANC
Out-of-pocket expenses or factors related to poverty	Nylander et al (1990)	Africa	MAT
	Monteith et al (1987)	Panama, Guatemala	MAT
	Swain et al (1992)	India	ANC
	Jaswal et al (1992)	India	ANC
	Abbas et al (1986)	Jordan	MAT
	Hamilton et al (1987)	South Africa	ANC
	McCoy (1997)	South Africa	ANC
	Fantahun et al (1995)	Ethiopia	ANC
	Owa et al (1992)	Nigeria	ANC
Opportunity cost (lost income)	Monteith et al (1987)	Panama, Guatemala	MAT
Quality of care or perceived health impact of health service	Voorhoeve et al (1984)	Kenya	DEL
	Marshall (1985)	Papua New Guinea	ANC
	Islam et al (1993)	Bangladesh	MAT
	Atkinson et al (1995)	Brazil	ANC
Previous use of health services	Monteith et al (1987)	Panama, Guatemala	MAT
	Dujardin et al (1995)	Zaire	DEL
	Marshall (1985)	Papua New Guinea	ANC
Cultural or family factors	Sargent (1985)	Benin	MAT
	Rahman et al (1982)	Bangladesh	ANC
	Marshall (1985)	Papua New Guinea	ANC
	Galloway et al (1994)	General	ANC
	Bamisaie et al (1986)	Nigeria	ANC
	Islam et al (1993)	Bangladesh	MAT
Poor education, literacy, general awareness of health services	Nylander et al (1990)	Africa	
	Monteith et al (1987)	Panama, Guatemala	MAT
	Nwakoby (1994)	Nigeria	DEL
	Jaswal et al (1992)	India	ANC
	Abbas et al (1986)	Jordan	MAT
	Ossis et al (1993)	Brazil	ANC
	Fawcus et al (1992)	Zimbabwe	ANC
Age, marital status and previous pregnancies	Nwakoby (1994)	Nigeria	DEL
	McCaw-Bins (1995)	Jamaica	ANC
	Abbas et al (1986)	Jordan	MAT
	Fawcus et al (1992)	Zimbabwe	ANC
	Lumbiganon (1991)	Thailand	ANC
Use of alternative health service	Nylander et al (1990)	Africa	MAT
	Jaswal et al (1992)	India	ANC
Weather patterns (e.g. rains)	Voorhoeve et al (1984)	Kenya	DEL

*Care type the study analyses: ANC – antenatal care; MAT – maternity care (any); DEL – delivery care.

Appendix 2: W.H.O antenatal care trial clinical component information

Trial background and rationale

According to experts, the 'industrialised model'¹ of antenatal care has never been properly evaluated with scientific objectivity (Fathalla 1998). Van Look (1998) claims that this fact is surprising especially in the context of 'resource-strapped' developing countries, given the cost of adopting the 'industrialised model' of antenatal care. Although many of the tests and screening procedures conducted during antenatal care have been studied in isolation, mainly in developed country settings, there has been limited evaluation of whole programmes of antenatal care, and thus of how these health care interventions work in combination. Until the middle of the 1990s there was limited evidence of the effectiveness of alternative programmes of antenatal care, such as the optimal content, timing and frequency of visits. More recently there have been a number of studies that showed no significant health effect of a reduction in the number of visits from 10 or more to four visits, but with more focussed health care interventions (Binstock and Wolde-Tsadik 1995, McDuffie et al 1995, Munjanja et al 1996, Sikorski et al 1996, Walker and Koniak-Griffin 1997). These findings at least provide some ex post rationale for the design of the WHO antenatal care trial².

Trial aims and objectives

The overall objectives of the W.H.O. antenatal care trial were (WHO 1996, page 8):

To conduct a multicentre, multi-country controlled trial comparing two models of ANC (the W.H.O. rationalised model versus the current standard of care).

- To establish the relative merits of each model.
- To test whether the proposed new model is more effective than the traditional multi-visit model with regard to maternal morbidity and mortality, satisfaction, *and cost* (italics added).

¹ The 'industrialised model' refers to the practice of antenatal care developed this century in European countries.

² Refer to Belizan et al (1998), Lindmark et al (1998), Khan-Neelofur et al (1998), and Villar et al (1998) for a more detailed rationale for conducting the antenatal care trial, with a focus on developing countries.

Therefore, the hypothesis of the trial was:

“A new model of antenatal care which includes only those components shown to be effective in improving maternal, perinatal and neonatal outcomes, is more efficient than the traditional model with regard to specific maternal and perinatal endpoints, among singleton pregnancies, and is not more expensive”. (WHO 1996, page 9)

Trial design

This trial was designed to be a multicentre multi-country randomised controlled trial. Trial centres were in Argentina, Cuba, Saudi Arabia and Thailand³ (see Table 1 for a description of these sites). As Pocock (1999) notes, the principal advantages of such a multicentre trial is that the intended sample size can be achieved more quickly than in a single centre trial, and also that the involvement of diverse settings allows conclusions to have a broader more representative base. Various aspects of the trial design relevant to the economic evaluation are described in this section, including the sample size, randomisation procedure, trial entry criteria, contents of the new ANC programme, health outcomes, data collection and data analysis methods.

Table 2.1. Study site location and allocation of clinics across sites.

Country	Site	Location	Population	Number of units
Argentina	Rosario	300 km from Buenos Aires	>1,000,000	2 large, 15 small
Cuba	Havanna	Capital city, North central coast	2,175,000	12 small
Saudi Arabia	Jeddah	Central part of country	1,500,000	4 medium, 8 small
Thailand	Khon Kaen	450 km North East of Bangkok	1,800,000	2 large, 6 medium, 4 small
South Africa	<i>Umlazi</i>	<i>20 km from Durban (East coast)</i>	<i>300,000</i>	<i>5 large</i>

(taken from Villar et al 1998; South Africa added in *italics*)

Sample size: Various extracts are taken from Donner et al (1998) in describing sample size issues: “The determination of sample size required for the trial corresponds to the stratified cluster randomisation design, taking into account that there are four study sites with clinics within each site randomly assigned to intervention or control... Further stratification was made by clinic size, to ensure balanced allocation of subjects across intervention groups. The approach for estimating the sample size requirements took account of the intracluster correlation coefficient, the stratum-specific event rates in the control group, and the value of the intervention odds ratio of interest to detect... With 12

³ These countries were chosen for two principal reasons:

- There was a minimum level of antenatal care in place to act as the comparison group.
- There was the basic infrastructure (researchers, facilities and data systems) for high quality work.

clinics per site, each clinic recruiting 450 patients, and 90% power for detecting an intervention odds ratio of 1.2 on a two-sided test with a level of significance of 5%, 19,087 subjects are needed in the four study sites... The value 1.2 was chosen as the maximum value of the odds ratio that would be regarded as consistent with the conclusion that the new programme is as 'equally effective' as the new programme. Assuming an average outcome rate across control group sites of 0.10, this implies that an elevation in this rate to approximately 0.12 is regarded as substantively important to detect" (Donner et al 1998, pages 62-64).

A relevant point to note here is that the sample size under a cluster design is bigger than would be required if patients were individually randomised, to take account of the fact that subjects' responses within a cluster cannot be regarded as statistically independent, thus reducing the effective sample size. Also, note that economic factors were not considered explicitly in calculating the sample size.

Randomisation procedure: The trial randomisation design was based on health facilities rather than patients ('cluster' design). This was necessary for three principal reasons (Donner et al 1998, page 61):

1. To reduce the risk of treatment contamination, which would be more likely to happen if two forms of ANC were being provided in the same clinic.
2. To encourage the participation of the women.
3. To facilitate logistic and administrative convenience in the implementation of the intervention.

Therefore, any woman reporting to one particular health care facility would receive the form of care that has been allocated to it, assuming she agreed to participate. Clinics were matched by size groups. However, clinics were not matched individually due to the difficulty of creating matched pairs on the basis of risk (Donner et al 1998). The allocation schedule for randomly assigning clinics was computer generated, stratified by study site and clinic size at W.H.O., Geneva.

Trial entry criteria: For women reporting for their first antenatal visit to intervention clinics, a risk classification form was applied. If the woman had any of the conditions

listed⁴ she was not eligible for the new programme, and was treated as a high risk patient in the usual way. If the woman was eligible for the new programme, she was informed about the aims and purpose of the new programme, and was asked if she would like to participate. If she refused to give her consent, she received the traditional form of antenatal care. The rate of non-participation, however, was very low. Informed consent was not necessary for women reporting to control clinics, as they would receive 'best standard treatment' as presently offered in the clinics.

The intervention: In each country at least six health facilities⁵ provided the new antenatal programme, and at least six the current model of care. The new programme consisted of tests, clinical procedures and follow-up actions scientifically demonstrated to be effective in improving maternal and newborn outcomes, avoiding the use of technology not affordable in developing country settings. These interventions were distributed among four visits over the entire course of pregnancy, with additional visits for women with signs of risk or symptoms/actual presence of disease, or if the woman insisted on more visits. Table 1 below provides a summary of the contents of the new ANC programme. Each country was responsible for monitoring compliance with the new protocol by making unannounced clinic visits, as well as investigating whether control clinics changed their ANC practice (contamination).

⁴ High risk women were excluded. High risk women were those that had a any one of the following conditions:

Obstetric history: previous stillbirth or neonatal loss, history of 3 or more spontaneous abortions, last baby <2500g or >4500g, hospital admission for hypertension or pre-eclampsia/eclampsia in the last pregnancy, previous surgery on reproductive tract,

- Current pregnancy: diagnosed or suspected multiple pregnancy, age less than 16 or more than 40 years, iso-immunisation Rh (-) in current or in previous pregnancy, vaginal bleeding, pelvic mass, diastolic blood pressure 90mm Hg or more at booking.
- General medical: insulin dependent diabetes mellitus, renal disease, cardiac disease, known 'substance' abuse, any other severe disease or medical condition.

⁵ In Cuba and Saudi Arabia, polyclinics; in Thailand, district hospitals; in Argentina, health centres & hospitals.

Table 2.2: W.H.O. antenatal care programme basic checklist

CHECK THE ACTIVITIES CARRIED OUT WHERE APPROPRIATE (UNSHADED BOXES)

Use the closest gestational age at the time of visit

Patient's Name

Clinic record No.

Study Subject No.

FIRST VISIT for all women at first contact with clinics, regardless of gestational age. If first visit later than recommended, carry out all activities up to that time DATE: / /	Visits 1 st 2 nd 3 rd 4 th <12 wks			
Classifying form indicates eligibility for the basic programme				
Clinical examination				
Clinically severe anaemia: Hb test				
Ob exam: gestational age examination, uterine height				
Gyn exam (can be postponed until second visit)				
Blood pressure				
Maternal weight / height				
Rapid syphilis test, detection of symptomatic STDs - treatment				
Urine test (multiple dipstick)				
Blood test and Rh				
Tetanus toxoid				
Fe / folic acid supplementation				
Recommendation for emergencies				
Complete antenatal card				
SECOND VISIT AND SUBSEQUENT VISITS DATE: / /	Gestational age - approx. # of weeks: 26 32 38			
Clinical examination for anaemia				
Ob exam: gestational age estimation, uterine height, fetal heart rate				
Blood pressure				
Maternal weight (only women with low weight at first visit)				
Urine test for protein (only nulliparous/women with previous eclampsia)				
Fe / Folic acid supplementation				
Recommendation for emergencies				
Complete antenatal card				
THIRD VISIT: add DATE: / /				
Hemoglobin				
Tetanus toxoid				
Instructions for delivery				
Recommendations for lactation / contraception				
FOURTH VISIT: add DATE: / /				
Detection of breech presentation and referral for external version				
Complete ANC card, recommend it to be brought to hospital				

Staff responsible for antenatal care: Name _____

Signature _____

Health outcomes: The effectiveness of the programmes was compared in terms of two primary outcomes: low birth weight and an index of maternal morbidity. In addition, several secondary outcomes and process outcomes (including perceived quality of care, satisfaction, and cost) were compared. However, during the implementation of the trial, the Steering committee gradually moved to regarding the trial as an equivalence study (health outcomes are not expected to differ significantly between arm) (Donner et al 1998).

Table 2.3: Outcomes of the W.H.O. antenatal care randomised controlled trial

OUTCOMES
A. Primary outcomes
Rate of maternal morbidity indicator index ⁶
Rate of low birth weight (< 2500 g)
B. Secondary outcomes
<i>Maternal</i>
Rate of treated syphilis and any other STD during pregnancy
Rate of postpartum positive syphilis test (among women without treatment during pregnancy)
Rate of incomplete tetanus immunisation
Rate of postpartum hospital stay ≥ 7 days for maternal complications
Rate of pre-eclampsia or eclampsia
Rate of postpartum anaemia
Rate of severe urinary tract infection
<i>Newborn</i>
Rate of intrauterine growth retardation ⁷
Rate of preterm delivery (< 37 weeks)
Rate of spontaneous and predelivery rupture of membranes (< 35 weeks, and 36-36 weeks)
Rate of medically indicated preterm delivery (< 35 weeks, and 36-36 weeks)
Rate of breech presentation at birth
Rate of very low birth weight (< 1500 g)
Rate of Apgar score < 5 at 5 minutes
Rate of intensive care unit stay > 2 days
Rate of fetal death (macerated stillbirth; fresh stillbirth)
Rate of neonatal death before discharge from hospital
C. Process outcomes
Rate of antenatal hospital admission – total and by cause
Rate of elective and emergency Caesarean section associated with pregnancy complications ⁸
Days of hospital admission during pregnancy (median)
D. Economic outcomes
Cost-effectiveness
E. Satisfaction outcomes
Rate of women satisfied with the two antenatal care models
Qualitative analyses of reasons underlying satisfaction / dissatisfaction

⁶ Maternal morbidity indicator index: the presence of at least one of the following conditions (1) pre-eclampsia or eclampsia during pregnancy or within 24 hr of delivery; proteinuria defined as 2.0g or more in 24 hr or 2+ or more on quantitative examination (dipstick); (2) postpartum anaemia (< 90 g/L); (3) severe urinary tract infection / pyelonephritis (requiring antibiotic treatment or hospitalisation but excluding the antibiotics given to treat asymptomatic bacteriuria).

⁷ If last normal menstrual period not available, use the best 'obstetric' estimate; below 10th percentile of international standard.

⁸ Excluding intrapartum Caesarean section for fetal distress or cephalopelvic disproportion.

Data collection and entry: Research centres within each country conducted the research and entered the data, with co-ordination and technical support from WHO. There were three main sets of data collection forms of relevance to the economic study:

1. The baseline survey forms. These surveys were conducted before the trial began, and collected data on health service structure, resources available, antenatal care content, and the incidence of pregnancy-related conditions and events. Two sets of forms were applied to collect these data (patient and clinic level forms).
2. The summary form. This was completed for all women, and recorded data on health care, health events and health outcomes, health service use covering the pregnancy and delivery period, and medical history and personal details.
3. The antenatal inpatient form. This was completed for all women admitted to hospital during pregnancy, and contained data on the principal reason for admission, and the length of stay of the woman.

Data analysis: Several aspects of data analysis in the clinical trial are of relevance to the economic evaluation, and therefore listed briefly. First, data were analysed only for those women who completed their pregnancies, and for whom at least one primary health outcome was available. Therefore women who (a) were found not to be pregnant after entering the trial (b) women who had abortions and (c) women lost-to-follow-up, were excluded from all analyses. Second, single and multiple births were reported separately, and only single births are analysed in keeping with the trial aims. Third, women were analysed on an intention-to-treat basis. Therefore, even if a woman did not comply with the new programme, she was still included in the intervention arm for the analysis.

Appendix 3: Economic paper for the trial

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Methods for economic evaluation alongside a multicentre trial in developing countries: a case study from the WHO Antenatal Care Randomised Controlled Trial

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Summary. The WHO is testing a new rationalised programme of antenatal care in a multicentre randomised trial. The motivation for this trial arose from the current uncertainty about the effectiveness of different approaches to provision of routine antenatal care. Decision makers also lack information about the costs of providing routine antenatal care and the cost-effectiveness of one programme over another. Such information will be needed before the final choice of programme can be made. The WHO trial provides an ideal opportunity to estimate and compare the incremental costs and cost-effectiveness of the new programme in four countries (Argentina, Cuba, Saudi Arabia, Thailand). A separate economic component has been organised to measure the costs of antenatal care. Methods for cost identification and measurement, and methods for economic analysis in the context of an international study are based on current recommendations for the conduct of economic evaluations alongside trials. However, several aspects require further development. In particular, this includes defining standard methods for costing in different countries; measuring women's costs of access to care; and making comparisons across international settings. The economic evaluation will also inform similar multicentre international trials and investigate issues of generalisability beyond trial settings.

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Introduction

Reproductive health is high on the agenda of many non-governmental and governmental international agencies, such as the WHO, the World Bank, Mother Care in the United States and the Department for International Development (DfID) in the United Kingdom. These agencies recognise that, although huge sums of money are being spent on reproductive health care, little of the expenditure is supported by good-quality evidence that can prove its value for money.¹ One purpose of health services research, and in particular randomised controlled trial methodologies, is to provide evidence to inform the more effective provision of services. The WHO Antenatal Care Trial^{2,3} has been designed for this purpose. It has also been designed to address the question of the economic efficiency or 'value for money' of the alternative patterns of care.

Economics is gaining increasing importance in health-care practice and research. Economic evaluation methods provide a framework to inform programme planners what the viable options are for intervention, and the levels at which they would best be implemented, taking into account the objectives of the intervention. Although costs are usually measured after health-care interventions have been implemented, many studies are now being reported in which costs have been estimated at the technology assessment stage of interventions.⁴ This allows early recognition of the relative efficiencies of health-care technologies, and allows those that are expensive and have limited health effects to be discouraged from being adopted more widely.

Reproductive health covers a broad range of health concerns, including sexually transmitted diseases, family planning, mother and child nutrition, health care for pregnant women and the newborn, and postnatal care. While there is some evidence about the effectiveness of screening and treatment procedures in antenatal care, among others, questions still remain about when and how often screening should take place and what treatment schedules are affordable.^{2,5} Only a handful of studies have evaluated the effectiveness of *programmes* of antenatal care, in which the interventions are assessed as a package rather than as several separate components of a package.⁶⁻¹¹ We have found only two such studies from the developing world, in Zimbabwe¹⁰ and The Gambia.¹¹ In The Gambia, a study of mobile antenatal clinics did not test alternative routine visiting patterns for outpatient antenatal clinics but evaluated whether reproductive outcomes were improved by taking care to women in remote areas. The studies that did evaluate routine visits suggest that antenatal care can be provided as effectively in fewer, more focused visits, but they have not reported clear evidence of the change in cost of care that would result. Therefore, the need to assess the cost-effectiveness of these antenatal care programmes remains.

Although the antenatal period is often quoted as being an important period for medical intervention, the evidence available about the cost-effectiveness of

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antenatal care is very limited,^{1,12,13} particularly in developing countries. However, evidence from developed countries is by no means adequate either.^{14,15} As a result, antenatal interventions in both developed and developing countries are based more on established clinical opinion than on scientific evidence.⁵ This is particularly true of recommended content and patterns of routine antenatal visits. Although there is increasing scientific evidence on the costs and effects of single interventions during pregnancy and childbirth, much of this research has been carried out in developed countries and is therefore biased towards the technologies available in high-income countries.¹²

The WHO antenatal care trial is comparing a rational programme of care with current routine antenatal care practice in cities or regions in four middle-income countries: Argentina, Cuba, Saudi Arabia and Thailand. The protocol for the trial has been based on reviews of evidence about effective clinical practice in antenatal care.^{2,5,12,16} Although the agreed protocol is being followed in every centre, the trial has a pragmatic design, allowing the new rational programme of care to fit in with local circumstances, such as who the main care givers are, or requirements to screen or treat particular conditions peculiar to that setting.

The clinical and statistical aspects of the trial are discussed elsewhere in this Supplement. Economic considerations were included in the design from the first stages of planning for the trial. Funds were granted by the United Kingdom DfID (formerly the ODA) for a pilot study that took place during 1996 to establish the feasibility of the additional data collection necessary for economic evaluation. In the pilot study, conducted during 1996, we found that the data were available, or could be collected, to estimate unit costs, and that local collaborators in each country were willing to supervise the work. Funds have now been granted for economic data collection in the centres in Thailand and Cuba for a two and a half year project, which will estimate the costs of the alternative antenatal care interventions and assess the cost-effectiveness of the new programme. Funds have also been granted as part of the same project by the DfID for a study in KwaZulu-Natal in South Africa to investigate international generalisability of the cost data beyond trial centres. We are still seeking funds to conduct the economic evaluation in Argentina and Saudi Arabia.

Aims of the economic evaluation

The aim of an economic evaluation, ultimately, is to provide evidence to estimate the net benefit or loss to society of adopting a particular policy. The aim is to help decision makers to establish whether the gain in health from a new programme of care is worth the cost of the additional resources used.

The objectives of the economic evaluation of the antenatal care trial are:

- to compare the costs of the new model of antenatal care with the traditional package of antenatal care

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- (if the WHO trial shows a difference in any of the primary outcomes) to assess the cost-effectiveness of the new model of care compared with the traditional package
- to explore whether the economic results of the trial are generalisable to other, lower-resourced settings.

The aims will allow us to address the primary hypothesis of the WHO trial: 'a new model of antenatal care which includes only those components shown to be effective in improving maternal, perinatal and neonatal outcomes, is more efficient than the traditional package with regard to specified maternal and perinatal end points, among singleton pregnancies, and is not more expensive.'²

It is important to note that, although the new package of antenatal care is expected to be cheaper, should it prove more expensive, it may still be considered as a more cost-effective option if the additional cost is accompanied by greater benefits.

The third aim of the economic evaluation reflects the priorities of the DfID, the agency funding the economic evaluation. The question of the applicability of the results of the WHO trial in poorer countries is of key importance to such agencies with responsibility for international aid for development of effective health services.

Other objectives of the economic evaluation include:

- local capacity building for health economics research, which is also a priority of the DfID and WHO
- collaborating with local policy makers, to assess their needs for information, and ensure the results of the economic evaluation are useful to them.

Methods for the economic evaluation

This study has been designed as a cost-effectiveness analysis (CEA) alongside a randomised controlled trial.¹⁷⁻¹⁹ In the CEA, changes in health are expressed in terms of the primary health outcome measured in the study, such as life-years gained, or in the case of the WHO trial, changes in the maternal morbidity index and rate of low birthweight. The costs of resources used in alternative treatment options will be compared in terms of these primary health outcomes. If there is no difference in the primary health outcomes of the alternatives, then the analysis is sometimes referred to as cost minimisation analysis (CMA).

Economic evaluation requires specification of:

- the question of the study
- the treatment alternatives
- the health outcomes
- the 'economic' outcomes
- the resources to be included in unit cost estimation
- the unit cost estimation method
- data collection

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- data presentation and analysis
- how issues of generalisability are to be dealt with.

Finally, before conclusions can be drawn about the cost-effectiveness of the new form of care, any uncertainty, weaknesses and limitations in the data definitions and measurement should be considered, and their impact explored in sensitivity analysis.

What is the question?

The central concern of this economic evaluation is that the new programme of antenatal care does not result in higher costs overall, to both the health services and to the women receiving care, than the currently practised antenatal programme.

Several other questions are relevant for interpretation of the meaning of the results from different viewpoints and for extrapolation to different settings:

- Is an antenatal visit more or less costly under the new programme of care?
- Which costs are borne by different agencies or participants? How much do estimates vary when different costs are included/excluded, such as women's time costs? The relative cost-effectiveness of the two programmes of antenatal care may change considerably when women's costs are included, as has been shown elsewhere.^{20,21} This leads us to ask whose viewpoint the analysis should represent. While it is important for an economic evaluation to adopt a societal perspective in order to illustrate where the most benefit could be gained, the costs of different agencies should also be presented separately, as they may highlight conflicts in incentive to change practice.
- How much do the costs of antenatal care vary by setting? If routine antenatal care is as effective but cheaper in primary health centres than in hospital clinics, this has important implications for where resources for low-risk care should be concentrated. Although it is not an objective of the trial to assess differences between types of clinic, information about cost variation may stimulate questions about relative effectiveness.

What are the treatment alternatives?

A second step in an economic evaluation is to identify and define the alternative intervention possibilities and choose which to evaluate. The interventions under comparison have been decided, and the rationale for this is provided elsewhere.³ The alternatives being compared are a new model of antenatal care, developed by experts, and the baseline model of antenatal care as currently implemented in the selected sites. The baseline models differ to some degree between the study sites,²² which may affect estimated differences between costs of the two programmes of care in the four trial centres. For example, the average number of visits in the

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baseline model of antenatal care varies from roughly four routine visits per women in Argentina to over eight in Cuba.

In each of the centres, outpatient antenatal clinics which provide routine antenatal care at community level based in health centres or attached to a hospital are the unit of randomisation. In some countries, such as Thailand, there are also primary-care health posts which may also be used to a greater or lesser extent by pregnant women, but these are not included as part of the programme being evaluated.

The WHO trial is based on cluster randomisation with clinics as the unit of randomisation. The population participating in the trial is women attending antenatal clinics in publicly funded health-care facilities, with the exclusion of those women classified as high risk. Socio-economic and epidemiological indicators collected alongside the trial show that women participating in the trial are likely to represent the majority of women eligible for routine pregnancy care in the participating countries.²² The advantage of the cluster design for the economic evaluation is that the unit of randomisation is also a key unit of health management and cost generation.

What are the health outcomes of the treatments?

The primary outcomes are an index of maternal morbidity and the rate of low birthweight. There are several secondary 'clinical' outcome measures, and these are listed in full elsewhere.³ The trial is also evaluating both women's and providers' views of care and their satisfaction with the health-care process. These views may relate either to the different frequency or to the different contents of the new programme of care, or both, compared with the traditional programme of care. Details of these outcomes are provided elsewhere.²³

What are the 'economic' measures?

The third group of outcomes being measured in the antenatal care trial indicate the quantity of resources used to provide health care. These, together with unit cost estimates for these items of resource use, allow estimation of differences in cost of providing care between the two programmes of antenatal care. These 'economic' outcomes relate to the changes in inputs required for the routine intervention and those required as a consequence of that care. This includes costs associated with routine care, provided at antenatal visits and during delivery, but also the other health-care costs associated with the progress of pregnancy and delivery, diseases and complications, and any inpatient stay that results. The elements of care we chose as outcome measures for the WHO trial were chosen

- to represent the range of care likely to be provided
- to be mutually exclusive

Table 1. Items of resource use chosen to estimate cost differences

-
- Antenatal care visits (routine and other)
 - Days of inpatient care during pregnancy
 - Days of inpatient care during labour, delivery and post partum
 - Surgical procedures associated with pregnancy and labour complications
 - Days of neonatal specialist care
 - Any other outpatient or inpatient postnatal care until six weeks after delivery
-

- to be reasonably homogeneous in cost between cases
- to minimise the extra data collection burden for trial participants.

As a result, the WHO trial includes data collection about the use of the different services listed in Table 1. We refer to these as *resource quantity* data. The work of the economics researchers is to estimate unit costs both for the health providers and for women for each of these types of care, to combine the costs and quantity data in cost analyses for the two arms of the trial and to compare the resulting cost differences with any differences in health outcome.

What resources should be included in unit cost estimation?

To estimate the unit costs of the health-care services listed above, we have applied the following criteria for an input type to be included in unit costs:

- the resource must either be an input to the health-care process, or be affected by it
- the resource must be relatively significant, that is, it must contribute significantly to the cost of the item of care
- the resource must be measurable in physical units
- the value of the resource must be convertible to monetary units via a unit price or cost.

In Table 2, we list the resource inputs that were found to have met these criteria during our pilot study. Some of these resources are involved directly in the health-care process, while some are inputs to overheads or support services, such as laboratory and management inputs.

Table 2. Items of resource input to health care included in cost estimation

-
- Staff
 - Drugs, medications and dietary supplements
 - Materials
 - Equipment
 - Vehicles
 - Utilities (gas, electricity, water, telephone)
 - Buildings and land
-

With respect to women's costs, the aim of the study is to estimate the net effect of attending antenatal care on women's own economic circumstances. Indicators of possible variations in costs that women bear in order to attend the antenatal clinic are listed in Table 3. We will also estimate the cost incurred by women in the trial who are delivered in private hospitals.

There are other social costs that may not be captured by measuring these costs alone, such as knock-on costs in the family and wider community. For example, a child may have to take the morning off school to look after a junior sibling, to enable the mother to attend the clinic. We will have data to estimate the degree to which such costs may be different between types of care, although not to quantify the overall economic impact.

How should unit costs be estimated?

Two main options are possible for unit cost estimation. The first option is to measure all the resources consumed by individual patients and then calculate the unit cost for each type of resource consumed. For example, for estimating the cost of an antenatal visit, this would involve recording all drugs, tests, staff time, equipment and so on, used by each of a selected sample of women attending a clinic. The cost per visit is then calculated using these data, together with the unit cost of each input. This is often termed the *bottom-up* approach. A second option is to estimate total resource cost for a given volume of patients, and the unit costs per patient are calculated, by dividing the total cost by the volume of service use. This is often termed the *top-down* approach. Each of these approaches has advantages and disadvantages, listed in Table 4. The distinction between methods is often one of degree. Usually some element of simplification and averaging is used in bottom-up exercises, and it is also frequently the case that bottom-up methods are needed to apportion top-down costs correctly between cases of different types. An advantage of top-down costing is that it ensures that the whole cost of the service is equal to the sum of the parts and that any errors of costing in one part will be offset by errors in other parts.

Table 3. Aspects of cost to women to be estimated in the study

-
- Travel costs (e.g. bus or taxi fare, or private car)
 - Out-of-pocket expenses for the antenatal visit (e.g. consultation fees, laboratory tests, prescription charges)
 - Other out-of-pocket expenses to attend the clinic (e.g. child-minding expenses)
 - Insurance premiums for government or private insurance schemes
 - Lost income as a result of attending the clinic
 - Opportunity costs of time spent travelling and in the clinic
 - Costs for a companion to accompany the women to the clinic
 - Other costs (e.g. dietary supplements, antenatal care received at private clinics)
-

Table 4. Some advantages and disadvantages of bottom-up and top-down costing

Bottom up	Top down
<i>Advantages</i>	
<ul style="list-style-type: none"> ● Measures details of inputs to costs more reliably ● Gives data on effects of case-mix (inter-patient variation) on costs ● Number of observations more likely to facilitate statistical analysis of cost variation ● Can be specific to women taking part in WHO trial 	<ul style="list-style-type: none"> ● Easy to perform ● Fewer data requirements ● Uses data routinely collected for accounts and management ● Less research time and less cost ● Fewer research skills needed ● Likely to cover all relevant inputs to care
<i>Disadvantages</i>	
<ul style="list-style-type: none"> ● Greater presence of cost researchers may disrupt clinical trial ● Can inadvertently omit or underestimate key inputs to care ● More complex primary research work ● More costly to perform research ● Overheads and joint costs are difficult to allocate between patients and activities 	<ul style="list-style-type: none"> ● No data about inter-patient variation within cost centres (e.g. clinics) ● Use of secondary data may require validation ● May be biased by inclusion of women not in the WHO trial

The bottom-up approach relies on more intensive primary research, based on interviews, case notes, observation and/or time and motion methods. Such an approach provides reassurance that details of inputs to costs are more reliably included, gives data on inter-patient variation, and also allows statistical analysis of cost variation within a health centre or clinic. The method can also be specific to women taking part in the WHO trial, whereas the top-down method at its simplest would estimate an average cost for all women attending a particular facility, regardless of their trial status. On the other hand, there are disadvantages to the detailed bottom-up approach to costing. The greater presence of economics researchers may disrupt the smooth running of the service and therefore the pragmatic nature of the clinical trial. This method can also inadvertently omit or underestimate key inputs to care. Where costing is based on observation of inputs used during patient contacts, it is possible to miss costs incurred for the care of the patient which do not occur at the time of patient contact. Examples of this might include a case conference, or time spent arranging referral between carers. A related difficulty in bottom-up costing, also found to some extent in top-down costing, is that overheads and joint costs are difficult to allocate between patients and activities. Finally, because the method requires more complex primary research work, it is more costly to do. Top-down methods are made easier by presence of available data. This is possible in centres such as those taking part in the WHO trial. Even where such data exist, however, we must reassure ourselves

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as to what is included in the costs, and whether accounting conventions are the same between the participating centres.

Choice of approach for estimation of unit costs

The advantages and disadvantages of the different methods can have different weights or priorities in different circumstances. In the context of the WHO antenatal care trial, the greatest constraint is the availability of research time, and this is needed in much greater quantity for the bottom-up method. Therefore, a top-down approach has been chosen, although this will be supplemented and validated by some bottom-up estimates. However, we also feel that a detailed bottom-up approach is unlikely to give more accurate data in these circumstances, because of the greater complexity involved in allocating overhead and joint costs between patients and activities. We are further justified in this decision by analyses comparing different methods of costing in cost-effectiveness analysis that suggest that more complex costing approaches do not result in significantly different estimates of cost difference.²⁴

The approach used for estimating unit costs in the WHO antenatal care trial is therefore a combination of the two approaches. Some unit costs, such as surgical procedures and laboratory tests, will be estimated using the bottom-up approach, because the procedures are heterogeneous and there are limited routine data available about these costs. Most other unit costs will be estimated using the top-down approach, where we have evidence that patients are more homogeneous in their resource use. For example, in the antenatal clinics, high-risk cases are often referred to higher level care, leaving only low-risk cases in the primary health clinics. Also, the care provided in different inpatient wards is usually determined according to intensity or type of care, thus separate unit costs can be estimated for different types of ward.

Data collection

Health-service costs

Data for costing are being collected at all of the participating clinics and associated hospitals where women receive care in Cuba and Thailand. Data forms have been designed to record the physical quantity and money value of resources at the participating health facilities. These facilities not only include those that have been randomised to either arm of the trial, but also those health facilities that provide secondary and higher levels of health care to women taking part in the trial. These will include central referral hospitals for high-risk cases, delivery and intensive care.

The data forms will be completed for each month for 1 year during the trial period by the economics researcher in Cuba and Thailand. The methods for

measuring the physical and monetary values were tested during the pilot study, and the results are summarised in Table 5. Although there will be some differences in measurement and valuation methods between study sites because of differences in both political context and data availability, the results will be presented in standard format to increase their international comparability. The sources of data depend largely on the degree of autonomy of the hospitals and clinics from the local health administration, which determines the amount of accounting and administrative information kept in the health facilities themselves. For example,

Table 5. Methods for measuring the physical and monetary values for each resource

Resource	Physical resource measurement	Monetary unit valuation
Health-care staff	Amount of health-care staff time spent in different activities, recorded by heads of departments	Add together salary, 'perks' allowances and overtime payments. Shadow prices in Cuba
Support staff	Amount of staff time spent working for each health-care department, depending on service use by the health-care departments	Add together salary, 'perks', allowances and overtime payments. Shadow prices in Cuba
Drugs, medications and supplements	Supplies consumed by pregnant women in health-care departments or from the pharmacy	Market or government-supplied prices. Shadow price estimates for imported items
Materials	Materials consumed by health-care and support departments	Market or government-supplied prices. Shadow price estimates for imported items
Equipment	Numbers of items in inventory, verified by the researcher	Monthly depreciation value (using replacement cost) plus maintenance. Shadow price estimates for imported items
Transport	Number of journeys and miles undertaken per month for pregnant women	Monthly depreciation value (using replacement cost) plus maintenance, staff and fuel costs. Shadow price estimates for imported items
Utilities	Quantity or value consumed by each department, measured using an appropriate allocation unit – e.g. number of taps for water costs	Monthly payments made to utility companies
Land and buildings	Number of buildings and land area, area occupied by clinic/ward	Monthly depreciation value (using replacement cost) plus maintenance cost

where there is centralised organisation of personnel and supplies, as is often the case, there may not be detailed record keeping at clinic level about the costs of these inputs.

The data sources chosen to measure the economic variables will be verified periodically to ensure that the data are accurate. For example, in Thailand, data collected on staff salaries and overtime will be compared with expenditure summary sheets sent to the Ministry of Health every month, and the budgets that are allocated to the hospitals. Information on equipment lists and unit prices will be compared between different sources of information, and any differences will be investigated.

Women's costs

A questionnaire to measure the costs borne by women was developed in each country during 1996. This provided the information to design a final questionnaire for women in the main economic study. The questionnaire will be administered by interviewers fluent in the local language and includes closed questions (with options for 'no response' and 'don't know') asking how the woman travelled to the clinic, the cost of the travel, how long she spent travelling and at the clinic, and whether she incurred other health-related costs in respect of this visit and more generally in this pregnancy. To estimate opportunity costs, we also ask about occupation, lost earnings and health insurance status. Over 300 questionnaires will be completed in each country for a sample of women in a representative sample of clinics in the WHO trial. To ensure that they represent the population of clinic attenders, the sample of women will include women having first or subsequent visits and will be analysed by whether they are attending intervention arm or control arm clinics. This part of the costing research will be coordinated as far as possible with the women's satisfaction survey, in order to minimise both the costs of research and disruption in the clinics.²³ The costs survey is being carried out separately from the women's satisfaction survey in Thailand and Cuba, but in Thailand the same researchers are conducting both costs and satisfaction surveys. A reduced form of the questionnaire has been designed for use in the two countries, Argentina and Saudi Arabia, where the economic evaluation is not yet funded.

The opportunity cost of women's time will be valued in monetary units, using a range of different approaches. These data will not be combined with out-of-pocket expenses. There is no consensus among economists on a single appropriate valuation method. For example, we will use an estimate based on valuation at average wage rates for women, and a more exact method based on what would have to be paid for the work which would have been done if the women were not at the clinic. Data on women's time costs will also be presented in natural units, to allow for cross-country comparisons of quantity of women's inputs to their own care.

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The data from this survey will be verified using information about local transport fares, local incomes for various professions and clinic charge schedules. Waiting times will be difficult to verify exactly without time-and-motion studies, which will not be an option.

Data presentation and analysis

Data from the health costing and survey of women will be collated to produce tables of costs

- at health facility level
- at country level
- at international level.

The first will be completed, as far as is relevant for each health facility, such as clinic or hospital ward. This summarises the costs of each of the key 'cost generating events' such as antenatal visits, a day of inpatient antenatal care, a normal delivery and so on, at each individual clinic or ward. From these data, the country-level tables can be constructed, which summarise the costs in the control and intervention arms at the country level. Finally, all country-level costs will be summarised with conversion to a common currency. This final stage allows an overall comparison of the costs in the control and intervention arms, which are combined with effectiveness data. Each table will indicate not only the average values at each stage but the variability of estimates.

In pooling and comparing data from each of the participating centres, local currencies will be converted into a common currency (US\$) using an official exchange rate and a *shadow exchange rate*, which reflects the full value of changes in foreign exchange. Current estimates of shadow exchange rates for each centre are available from international agencies such as the World Bank.²⁵ Cost estimates based on exchange rates can overestimate real purchasing power. Therefore, currencies will also be adjusted using purchasing power parities. These are calculated by comparing the costs of similar bundles of goods in a common currency and, again, can be collected from international agencies.

Interpretation of the cost differences between countries is complicated by the methodological difficulties of such conversions. It is therefore also important to express differences in natural units, such as units of types of health-care staff time. If the skills and input values are similar across countries, these data can be compared across currency borders. This is particularly important in the WHO antenatal care trial, which includes centres within countries of types of economies as diverse as Argentina, Cuba, Thailand and Saudi Arabia. There can be no assumption that relative and absolute prices within these countries reflect similar values.

Cost data will also be presented in a variety of 'cost profiles' for each type of health care costed, showing the proportion of each resource used, comparing and contrasting the health facilities within and between the four study centres.

Differences in costs and effects of the two programmes of care will be combined to estimate the incremental cost-effectiveness of one programme over another. This identifies the cost associated with a given change in health effect. If one programme is both more effective and less costly than the other, and if there are no other unmeasured factors that would alter choices, then it is dominant and should be adopted widely. If one programme is more effective and more costly than the other, then the results will inform society of the extra cost of an increase in a specified health gain.

Before any conclusions are made, any assumptions and uncertainties should be tested. This is done using *sensitivity analysis*. This will include testing whether the inclusion of women's costs has any impact on the result. The possible influence of future costs will be tested, such as a reversal of the relative effectiveness of the programmes after 6 weeks post partum. Finally, the sensitivity of the results to changes in the cost of resources, such as staff time input and unit prices, will be tested in a multiway sensitivity analysis.

Issues of generalisability of the costs and cost-effectiveness within and beyond the WHO trial centres

Health-service costs and women's costs will not be combined into a single cost estimate, for reasons already given. For each of these two broad areas of cost, however, costs can be compared assuming the shadow pricing and purchasing power parity weighting method can be justified to express the relative values of resources between different countries. Because the baseline programme of antenatal care, which forms the control group for the WHO trial, may differ substantially between countries,²² comparison of average costs across trial centres for 'baseline' care and differences between the new and baseline programmes may be fairly meaningless. Therefore, the costs and outcomes in control clinics will be compared considering, in sensitivity analysis, whether the differences affect overall conclusions about the cost-effectiveness of the new programme of care. However, in a developed country, comparison of drug treatment for gastric ulcer, Drummond and his colleagues²⁶ conclude that, despite practice variations in the countries they studied, the similarity of results in four countries greatly increases their confidence that cross-national assessments of health technologies are both feasible and useful.

The generalisability of cost and cost-effectiveness evidence will be an important consideration in collecting and analysing the trial data. For this purpose, data on health services will also be collected in other lower-resourced settings, to investigate the feasibility of generalising cost and cost-effectiveness data. The countries to be included in this part of the analysis include South Africa, The Gambia, Zimbabwe, Indonesia and Bangladesh. The choice represents countries where the authors have contacts in Maternal and Child Health activities.

South Africa is a special case, as funds have been granted by the DFID to investigate the issue of generalisability in depth. This research will take place in KwaZulu-Natal province.

From the data collected from 'non-trial' countries, investigations will be made of whether enough resources are available to adopt either programme of care, and whether the skills are available to deliver it as effectively as in the antenatal care trial. Data will be collected on local characteristics and features of the health service, including prices, morbidity and utilisation patterns. Also, women's costs will be modelled in these countries, based on local prices, practices and utilisation patterns.

There are several factors that must be recognised in pooling the data and interpreting the results from the economic evaluation of the trial. First, because of the diversity of the settings taking part in the trial, the trial protocol has minor differences in each country. This relates to both local government laws on minimal health care for pregnant women and local morbidity patterns. For example, in Cuba there are several compulsory home visits by nurses, which could be interpreted as additional antenatal visits (as they might lead to better outcomes). Also, in Argentina, diagnosing and treating Chagas' disease will still take place in the intervention arm of the trial, with its associated costs and benefits, despite not being in the WHO protocol. In both cases, as these externally imposed aspects of care occur in both arms of the trial, they will not be included in the economic evaluation. They will only affect the evaluation in the degree to which they alter women's health status and use of antenatal services within that trial centre.

Secondly, women may make visits to private clinics during their pregnancy, and these may not be recorded in the summary forms. The problem is that such visits both increase the costs of antenatal care and may alter the outcome of pregnancy; however, they will not necessarily be captured in the economic evaluation. Efforts will be made to identify these visits in the women's cost questionnaire. If the number of visits to private clinics is high, and varies between arms of the trial, then some steps will have to be taken to include associated costs. On the other hand, outcomes for women recruited to the trial who deliver in private hospitals or at home will be recorded in the trial summary form.

Thirdly, there are several costs that the health facilities incur that are associated with the trial only and would not continue after the trial has ended. These costs are related to the additional form filling required for the trial. The economic evaluation will exclude these costs, however.

Fourthly, the countries in the WHO trial have such different economic structures that it will be very difficult to ensure equivalent methods for estimation of opportunity costs. If distortions are found to exist in the market, then the market price does not represent the true opportunity cost of the resource and alternative values must be sought. For example, in the case of government salaries for health-sector workers, the price paid to labour may be artificially depressed because of government control of prices. In this case, the private-sector rate should

be examined, if it exists, although this again may be artificially high because of government-imposed restrictions or punitive tax rates. The approach being adopted is to conduct the analysis with both public- and private-sector values, giving an upper and a lower limit for the costs of health-care staff, between which the true opportunity cost is likely to fall. In Cuba, where almost all health-care workers work in the public sector, the opportunity cost will be constructed using all forms of payment, both monetary and in kind, made by the State to employees.

Study organisation and collaboration

The economic evaluation is being administered by the UK project team (MM, GH and JF-R) and is based jointly at the University of East Anglia and the London School of Hygiene and Tropical Medicine. In addition to the UK project team, there will be research teams in Cuba, Thailand and South Africa. While we have so far been unsuccessful in seeking funds for data collection in Argentina and Saudi Arabia, we still hope that costs will be estimated at all those health facilities participating in the clinical trial in these countries. The research teams in Cuba, Thailand and South Africa will run their economic evaluation with support from the UK team members. Each centre is responsible for producing a report of results within the centre, and a comparative report will be written by the UK team in collaboration with the research teams in each centre.

Discussion

The WHO antenatal care trial, and associated economic evaluation, provides a unique opportunity to measure the costs of antenatal care prospectively, alongside the actual health-care processes for which effectiveness is being measured. There is much excitement about the data that will be forthcoming from such a large multicentre trial as this one, which is the first of its kind in reproductive health. In this paper, the methods have been described for evaluating whether a new, 'evidence-based' programme of antenatal care will be more or less costly for the health service and for women, and whether it would be more cost-effective. The methods reflect the state-of-the-art in multicentre economic evaluations.

Two broad issues will affect the interpretation of the results of this study. The first is the confidence we can have that the results represent local cost differences, which in turn depends on the completeness and validity of research methods and assumptions. The second is whether the results can be combined to predict a general relationship between costs and outcomes of antenatal care, both within the range of the study centres and also extrapolated from them to other countries and settings.

The reliability of results is enhanced by the association of the economic study with a carefully designed randomised trial, in which bias is minimised regarding the differences in quantities of service used. However, there is less certainty about

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the methods for estimating unit money costs. Practical measurement of the derived cost variables has not been an area of research that has received much attention from health economics methodologists, and the methods used in this study are little tested.

There may be broader, long-term economic effects on the population or health service that have not been accounted for in the instruments of the clinical, economic or satisfaction components of the trial. For example, if the new programme of care eventually leads to lower fertility rates, there would be long-term social and health service implications. However, it was not within the scope of this study to address these issues. Furthermore, the economic evaluation will only measure the short-term costs and consequences of care. This is largely due to the fixed end point of the trial at 6 weeks post partum, but is also because it would require a larger research effort than can be managed within the available resources. If there are large changes in short-term severe maternal morbidity as a result of the new programme, then there are likely to be associated longer-term economic changes.

Finally, policy implications of the results have been considered in shaping both the methods and the presentation of the data. The costs of adopting the new programme of care as routine practice will be calculated for the participating centres, and cost simulations will be made for non-trial settings. This will give an indication of the changes in budget requirements, investment in certain resources and other essential changes for a newly adopted programme of care to be successful.

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Appendix 4: W.H.O. antenatal care trial economic evaluation information**Table 4.1: Calculation of purchasing power parities**

Food item	Quantity	Thai	Cuba	South Africa	UK	USA ¹
		Baht	Centavo	Rand	Pence	Cents
Rice	1 kg	19.5	50	4.1	69	111
Sugar	0.5 kg	13	50	2.15	45	72
Bread	3 loaves	55	80	6.4	34	55
Dried beans	1 kg	75	70	5.1	95	153
Eggs	6	12	60	2.95	75	121
Chicken	1 kg	44	100	8.5	245	394
Cooking oil	0.5 litre	14	30	3.15	39	63
Salt	0.5 kg	3.5	30	0.74	25	40
Milk	1 litre	29	16	2.84	52	84
Potato	1 kg	45	40	2.5	76	122
Coffee	0.1 kg	42	40	4.1	53	85
Tea	25 bags	20.6	15	1.5	52	84
Total cost (all items)		372.6	581	44.03	860	1385
Official exchange rate	Actual	52.3	1	4.93	0.62	1
Cost in US\$ at OER	Actual	7.12	5.81	8.93	13.85	13.85
PPP exchange rate	Estimated	26.91	0.42	3.18	0.62	1
Adjustment	Estimated	1.94	2.38	1.55	1.00	1

Table key: ¹ This is estimated from the UK price data, as the bundle of goods was not estimated in USA. It was necessary to estimate the prices in US\$ so that comparisons could be made between official exchange rates and PPP with the US\$. The UK: US\$ exchange rate was US\$1 = UK0.621

As there were no international estimates available for purchasing power parities (PPP) values in Cuba, it was decided to estimate our own 'bundle of goods' in all the study countries in order to maintain consistency between countries. The items were chosen based on what was considered to be essential foodstuffs that were available in all countries, and the quantities were chosen based on expected consumption in roughly a 2 week period.

Therefore, to get US\$ values using PPP, the US\$ values for each country (obtained using OER) are multiplied by the adjustment factor in the last row.

Table 4.2: Step-down allocation for calculation of unit costs in Cuban policlinics

CENTRE Resources	COSTS	ALLOCATED TO	USING
SERVICES Staff Equipment Materials Buildings Overheads	DIRECT COSTS	ADMINISTRATION LABORATORY TECHNICAL SUPPORT FAMILY DOCTOR CLINIC OBSTETRICS OTHER SPECIALISTS	% FULL TIME EQUIVALENTS (TOTAL - SERVICES)
ADMINISTRATION Staff Equipment Materials Buildings Overheads	DIRECT COSTS + Allocated from SERVICES	LABORATORY TECHNICAL SUPPORT FAMILY DOCTOR CLINIC OBSTETRICS OTHER SPECIALISTS	% FULL TIME EQUIVALENTS (TOTAL-SERVICES- ADMIN)
TECHNICAL SUPPORT Staff Equipment Materials Buildings Overheads	DIRECT COSTS + Allocated from SERVICES & ADMINISTRATION	FAMILY DOCTOR CLINIC	%VISITS
		OTHER SPECIALIST CLINICS	%VISITS
		OBSTETRICS	INCLUDED IN F.D.C.
EXTERNAL PHARMACY Staff Equipment Materials Buildings Overheads	DIRECT COSTS	CLINICS (1)	%VISITS
		OTHER SPECIALIST CLINICS	%VISITS
		OBSTETRICS	INCLUDED IN CLINICS
LABORATORY Staff Equipment Materials Buildings Overheads	DIRECT COSTS + Allocated from SERVICES & ADMINISTRATION	CLINICS(ANC)(i)	%PREGNANT TESTS
		REMAINDER	%NOT PREGNANT TESTS
F.D.C. (I) Equipment Materials Buildings Overheads	Allocated from SERVICES ADMINISTRATION TECH. SUPPORT EXT. PHARMACY	CLINICS(2)	%CLINICS VISITS
		FIELD(1)	%HOME VISITS
F.D.C. (II) Staff	DIRECT COSTS	CLINICS(3)	%CLINICS TIME
		FIELD(2)	%HOME TIME
		OTHER	%OTHER TIME
F.D.C. (III) Equipment, Materials, Buildings, Overheads	DIRECT COSTS	CLINICS(4)	100%
OBSTETRICS Staff Equipment Materials Buildings Overheads	DIRECT COSTS + Allocated from SERVICES & ADMINISTRATION	CLINICS(ANC)(ii)	%CLINICS TIME
		FIELD(ANC)(j)	%HOME TIME
		OTHER	%OTHER TIME
CLINICS (1)+(2)+(3)+(4)	Allocated from EXT. PHARMACY & FDC (I, II, III)	CLINICS(ANC)(iii)	%CLINICS PREGNANT VISITS
FIELD (1)+(2)	Allocated from FDC (I, II)	FIELD(ANC)(jj)	%FIELD PREGNANT VISITS

The calculation of Antenatal Care Costs in Clinics (ANC CL COST) and Fields (ANC FIELD COST) used the following formulae:

-ANC CL COST=CLIN(ANC)(i)+CLIN(ANC)(ii)+CLIN(ANC)(iii)+DRUGS

-ANC FIELD COST= FIELD(ANC)(j)+ FIELD(ANC)(jj)

(Clinic unit cost = ANC cl cost / clinic throughput)

Table 4.3: Background and tasks of research team members in study countries.

Country and collaborator	Background and training	Tasks in economic study
Cuba		
Ana Maria Galvez (PI)	Health economist	Supervision and data collection
Manuel Alvarez	Geographer and health planner	Data entry and processing
Dr Giselda Sanabria	MD and social science researcher	Women's costs (collection, entry, analysis)
Dr Martha Morales	MD	Data collection
MPH students	MD	Data collection
Thailand		
Dr Jadsada Thinkhamrop (PI)	Obstetrician	Supervision
Dr Bandit Thinkhamrop	Statistician	Supervision and data collection
Chusri Chaisiri and Chintana	Nurses and social science	Women's costs (collection, analysis)
Leela Kraiwan and others	researchers	
Hospital staff	Nurse	Data collection
South Africa		
Prof Noddy Jinabhai (PI)	Doctor of Community Health	Supervision
Joseph Wamukuo	Health economist	Data collection
Dr Chauntelle Bagwandeem	Obstetrician	Supervision and data collection
Four research nurses	Nurse and social science researcher	Data form administration
Others	Various research staff	Questionnaire translation and statistical support

Table key: PI – Principal Investigator; MD – Medical Doctor

Table 4.4: Site visit details by UK research team

Country and dates	Person	Purpose of trip
Cuba		
June 1996	GH (1 month)	Identify economics collaborators Assess data availability
July 1997	GH (1 month) JFR (2 weeks)	Set up data collection Train local collaborators
April 1998	GH (10 days) MM (10 days)	Assess progress
December 1998	GH (2 weeks) JFR (1 week)	Finalise data collection Agree further plans
Thailand		
March 1996	GH (1 month) MM (2 weeks)	Identify economics collaborators Assess data availability
September 1997	GH (1 month) MM (10 days)	Set up data collection Train local collaborators
August 1998	GH (2 weeks)	Finalise data collection Agree further plans
South Africa		
July 1996	GH (1 month)	Identify economics collaborators Assess data availability
November 1997	GH (1 month)	Set up data collection Train local collaborators
November 1998	GH (3 weeks)	Finalise data collection Agree further plans

Table key: MM – Miranda Mugford; JFR – Julia Fox-Rushby; GH –Guy Hutton.

Table 4.5: Sources of uncertainty and alternative values - Insufficient observations on a parameter

Area of uncertainty (criticism)	Base case	Alternative value(s) or design
Number of months of data collection was insufficient in Cuba and South Africa, and therefore do not reflect the seasonal variation over a year period	15 months of data in Thailand 8 months of data in Cuba 4 months of data in South Africa	1. Examine Thai data set to see the extent to which reductions in number of months impact on unit costs. Apply the % unit cost impact to Cuban and South African data to get new ranges.
Number of women from whom drug costs were collected for outpatient visits may not be sufficient	Antenatal cards of 12-15 women per health facility in Cuba and Thailand (not done in South Africa)	1. Combine all health facilities in same arm to increase sample size, and apply the averages within each arm (outpatient visits only). 2. Examine why drug cost per visit varied between health facility.
Material and drug costs were averaged over the period of the study, and the average was applied to each month (data systems did not record actual usage)	Thailand: materials and inpatient drugs in district hospitals Cuba: materials in polyclinics	Other data were not collected, and therefore it is unclear how alternative value(s) can be supported
The actual use of utilities by each department was not measured	The number of utility 'outlets' was used to proxy utility usage	Other data were not collected, and therefore it is unclear how alternative value(s) can be supported
Numbers of uses of support and overhead departments by each other and by health care departments is unknown	Number of full-time equivalents were used to proxy the use between cost centres	Other data were not collected, and therefore it is unclear how alternative value(s) can be supported
The connection between cost centres was not measured for step-down allocation of costs, and step-down allocation was not simultaneous.	Cost centres were categorised according to likely uses by other cost centres, and one-way step-down allocation.	1. Inaccuracies of +/- 20% were assumed, based on a previous study that measured inaccuracy of not using simultaneous methods (Graves 1998), and unit costs recalculated based on these alternative values
'Average' costs do not take account of different case-mix between pregnant women and other patients	Thailand: Inpatient care in district hospitals reflected general inpatients. Cuba: Outpatient care in polyclinics reflected general population (except drug cost). In all countries: laboratory test unit cost reflected the 'average' test	Other data were not collected, and therefore it is unclear how alternative value(s) can be supported

Table 4.6: Sources of uncertainty and alternative values - Inaccuracies in recording systems

Area of uncertainty (criticism)	Base case	Alternative value(s) or design
Material recording systems were poor quality in Thailand and Cuba	Available data were collected, and some generalised across hospital in Thailand	Other data were not collected, and therefore it is unclear how alternative value(s) can be supported
Historic prices for equipment and buildings are outdated.	Historic prices of equipment and buildings were inflated by estimates of the age.	1. Increase by arbitrary amount (50%), to reflect what equipment could cost in the international market

Table 4.7: Sources of uncertainty and alternative values - Uncertainty over the best method to value a parameter

Area of uncertainty (criticism)	Base case	Alternative value(s) or design
Salary costs may not represent opportunity cost	In all countries, gross salary costs plus accommodation costs were used.	1. In Thailand and South Africa, the public sector wage was increased 50% to reflect roughly the private sector wage. 2. In Cuba, wages were arbitrarily increased to reflect the cost.
The method used for annualising capital items was only approximate.	Number of months for categories of equipment was estimated using adjusted historic prices, and straight-line depreciation	1. The number of months of life of equipment of buildings was arbitrarily halved and doubled, thus doubling and halving the monthly cost.
Utility costs may not represent opportunity cost	The costs incurred by the health facilities (charged by the companies) were used.	The subsidy/profit margins of the utility companies is unknown. Therefore no adjustments were made.
Exchange rates do not reflect the shadow (socially optimal) exchange rates.	Official exchange rates and purchasing power parity were used (January 1997).	1. The black market exchange rate was used for NTG in Cuba 2. May 1999 OERs were used for Thailand and South Africa.

Table 4.8: Sources of uncertainty and alternative values - Uncertainty over generalisability of values across settings

Area of uncertainty (criticism)	Base case	Alternative value(s) or design
No data to support whether unit costs can be generalised across (referral) hospitals	Thailand: Unit costs generalised to referral hospital. Cuba: America Arias unit costs were used in Naval and other maternity hospitals	Other data were not collected, and therefore it is unclear how alternative value(s) can be supported. Uncertainty already reflected within ranges in sensitivity analysis.
Material and drug costs were generalised over time or space	Cuba: In America Arias, 1996 material and drug costs were adjusted by differences in throughput. Thailand: material costs generalised for 2 hospitals.	Other data were not collected, and therefore it is unclear how alternative value(s) can be supported. Minimum impact expected.
Statistics data generalised between health facilities	Cuba: In Romay, statistics data were not available, and were generalised from surrounding policlinics	Other data were not collected, and therefore it is unclear how alternative value(s) can be supported

Table 4.9: Measurement and data sources of patient factors determining health service use

Patient factors determining health service use	Data being used	Data source
Geographical accessibility	Average distance from the clinic Average time from the clinic Availability of transport Average cost of transport	Women's cost survey Women's cost survey Women's cost survey Women's cost survey
Cost of health care services	Cost of consultation Cost of medicines	Women's cost survey Women's cost survey
Ability to pay expenses	Average income versus costs	Women's cost survey
Other expenses of visit	Cost of food and drink	Women's cost survey
Opportunity cost	Proportion of women with jobs Time taken off work Paid leave to attend ANC Average salary	Women's cost survey Women's cost survey Women's cost survey Women's cost survey
Availability or use of alternative services	Alternatives services available Amount of use of alternatives	Women's cost survey Women's cost survey
Familiarity with and use of health services	% first pregnancies National average ANC visits % institutional delivery rates	ANC trial summary forms Ministry of Health documents ANC trial summary forms
Perception of quality of care	% of women happy with service	ANC trial satisfaction survey
Education and socio-economic status	Average age Marital status Number of years of education Average rooms per house	ANC trial summary forms ANC trial summary forms ANC trial summary forms ANC trial summary forms
Cultural attitudes to modern health services	Cultural acceptability of services Need for permission from family	ANC trial satisfaction survey ANC trial satisfaction survey
Attitudes to risk	Desire for minimum ANC visits	ANC trial satisfaction survey
Risk levels	Outcomes of previous pregnancy Presence of other risk factors	ANC trial summary forms ANC trial summary forms
Morbidity levels	Presence of morbidity	ANC trial summary forms
External factors	Weather patterns	Excessive rain, heat or cold

Table 4.10: Measurement and data sources of provider factors determining health service use

Provider factors affecting health service use	Data being used	Data source
Financial incentives to providers	Fee schedule Other payments to health providers	General knowledge of systems Women's cost survey
Compliance with standards of care	General contents of ANC Compliance with WHO checklist Monitoring systems in place	WHO baseline survey Unannounced observations Morbidity targets
Quality or effectiveness of health care staff	Training level of main providers Availability of diagnostic equipment On-going refresher courses	Costing study Costing study Costing study
Health care provider risk aversity	National norms for dealing with risk Risk referral practices	National guidelines ANC trial summary forms
Capacity use of health facilities	Average % of capacity used	Costing study

Table 4.11: Risk factors in multiple regression analysis

VARIABLE	HYPOTHESISED RELATIONSHIP TO COST	EXPECTED SIZE	MULTICOLLINEARITY	VALUE DEFINITION
Women's a priori risks				
Age	Young and old women expected to receive more medical attention	Unknown, probably minimal	With age category (below)	Continuous variable
Schooling	Women with more schooling are likely to attend medical care	Unknown, probably minimal		Continuous variable
Smoking	Women who smoke are more likely to have adverse outcomes	Unknown, probably minimal	Possibly with substance abuse	0 = no smoking; 1 = smoking
Substance abuse	Women who abuse alcohol or take drugs are more likely to have adverse outcomes	Unknown, probably minimal	Possibly with smoking	0 = no substance abuse; 1 = substance abuse
Previous pregnancies	Women in first pregnancy are at higher risk and are expected to receive more medical attention	Unknown, probably minimal	Age	0 = first pregnancy; 1 = repeat pregnancy
Previous stillbirth / NN loss	Women with previous stillbirth more likely to receive more medical attention and have adverse outcomes	Unknown, probably minimal	Possibly with pr. pregnancy and pr. adverse outcome	0 = no previous stillbirth / NN loss; 1 = previous stillbirth / NN loss
Previous abortion	Women with previous abortion more likely to receive more medical attention and have adverse outcomes	Unknown, probably minimal	Possibly with pr. pregnancy and pr. adverse outcome	0 = no previous abortion; 1 = previous abortion
Last baby LBW	Women with last baby LBW more likely to receive more medical attention and have adverse outcomes	Unknown, probably minimal	Possibly with pr. pregnancy and pr. adverse outcome	0 = last baby not LBW; 1 = last baby LBW
Hospital admission in last pregnancy for HDP	Women with hospital admission in last pregnancy more likely to receive more medical attention and have adverse outcomes	Unknown, probably minimal	Possibly with pr. pregnancy and pr. adverse outcome	0 = no admission in last pregnancy; 1 = admission in last pregnancy
Previous surgery on reproductive tract	Women with previous surgery on reproductive tract more likely to receive more medical attention and have adverse outcomes	Unknown, probably minimal	Possibly with previous pregnancy adverse outcome	0 = no previous surgery on reproductive tract; 1 = previous surgery on reproductive tract
Previous iso-immunisation	Women with previous iso-immunisation more likely to receive more medical attention and have adverse outcomes	Unknown, probably minimal	Possibly with previous pregnancy adverse outcome	0 = no previous iso-immunisation; 1 = previous iso-immunisation
Last pregnancy adverse outcome	Women with last pregnancy adverse outcome more likely to receive more medical attention and have adverse outcomes	Unknown, may be significant	Likely to be positively related to all other previous outcome variables	0 = last pregnancy not adverse outcome; 1 = last pregnancy adverse outcome

Table 4.12: Pregnancy and delivery events in multiple regression analysis

VARIABLE	HYPOTHESISED RELATIONSHIP TO COST	EXPECTED SIZE	MULTICOLLINEARITY	VALUE DEFINITION
Pregnancy events				
Week at which first reported	Women reporting later are likely to have less ANC visits, but possibly more adverse outcomes	Unknown direction or size of cost impact	Possibly with ANC visits	0 = first visit <20 weeks; 1 = first visit >20 weeks
Referral to higher level	Women referred are more likely to receive more medical attention	Expected significant impact on costs	May be related to pregnancy event	0 = no referral; 1 = referral
Pregnancy event (HDP/UTI/haem/anaemia/STD).	Women with pregnancy event are more likely to receive more medical attention	Expected significant impact on costs	May be related to referral to higher level	0 = no event; 1 = pregnancy event
Events around delivery				
Preterm	Women pre-term likely to receive less ANC visits	Probably minimal	-	0 = normal term; 1 = preterm
Postterm	Women postterm likely to receive more ANC visits	Probably minimal	-	0 = normal term; 1 = postterm
Prelabour rupture of membranes	Women with PROM more likely to receive medical attention, and babies more neonatal care	Unknown, probably minimal	-	0 = no PROM; 1 = PROM
Condition at labour	Women with adverse condition at labour more likely to receive medical attention during pregnancy and delivery	Expected significant impact on costs	Possibly related to pre-term and PROM	0 = condition normal at labour; 1 = adverse condition at labour
Fetal presentation at delivery	Women with adverse fetal presentation at delivery more likely to receive medical attention	Expected significant impact on costs	Possibly related to condition at labour	0 = cephalic presentation at delivery; 1 = breech presentation
Labour induced	Unclear	Unknown	Possibly related to condition at labour and post-term	0 = normal; 1 = labour induced
Elective caesarean section	Women with elective CS more likely to receive medical attention	Expected significant impact on costs	Possibly related to condition at labour and fetal present.	0 = vaginal delivery or emergency CS; 1 = elective CS
Postpartum information				
LBW (very LBW and LBW categories, cont.)	LBW babies more likely to receive neonatal care	Expected significant impact on costs	May be related to previous LBW and neonatal ICU	0 = >2500 grammes; 1 = <2500 grammes; also continuous
Apgar score (1 minute, 5 minutes)	Babies with low apgar scores (especially at 5 minutes) more likely to receive neonatal care	Expected impact on costs	May be related to LBW, cong. mal. and neonatal ICU	Continuous variables
Postpartum anaemia	Women with postpartum anaemia more likely to stay longer following delivery, and have had adverse event	Unknown, probably minimal	May be related to pregnancy event	0 = no postpartum anaemia; 1 = postpartum anaemia
Postpartum syphilis	Women with postpartum syphilis more likely to stay longer following delivery, and have had adverse event	Unknown, probably minimal	May be related to pregnancy event	0 = no postpartum syphilis; 1 = postpartum syphilis
Congenital malformation	Malformed babies more likely to receive neonatal care	Expected significant impact on costs	May be related to LBW and neonatal ICU	0 = baby not malformed; 1 = baby congenitally malformed

Table 4.13: Provider characteristics and women's health service use in multiple regression analysis

VARIABLE	HYPOTHESED RELATIONSHIP TO COST	EXPECTED SIZE	MULTICOLLINEARITY	VALUE DEFINITION
Provider characteristics				
Throughput per staff FTE	Health facilities with lower outpatient visits / IPD per staff FTE more likely to have higher costs	Expected significant impact on costs	-	Continuous variable
Occupancy	Health facilities with higher occupancy more likely to have lower costs	Expected significant impact on costs	-	Continuous variable
Health facility throughput	Larger health facilities may have different costs on account of their size	Unknown size and direction of impact	-	Continuous variable
Health facility	Some health facilities, due to high or low unit costs and health service use, have different cost per pregnancy	Expected significant impact on costs	May be related to trial arm	Continuous variable 0 = Median facility (6/12)
Practising new or old model	Women receiving care under WHO programme likely to receive less ANC visits	Expected significant impact on costs	-	0 = practising control ANC; 1 = practising intervention ANC
Health service use				
Inpatient admission during pregnancy	An inpatient admission during pregnancy is likely to increase costs	Expected significant impact on costs	May be correlated with some risk factors/pregnancy event	0 = no admission; 1 = admission
Type of delivery	A caesarean section will increase costs	Expected significant impact on costs	May be correlated with some risk factors/pregnancy event	0 = vaginal delivery; 1 = caesarean section
Neonatal admission to intensive care unit	Neonatal admission will increase costs	Expected significant impact on costs	May be correlated with CS, and health of neonate	0 = no admission; 1 = admission

¹ This is because all trial women cost the same in America Arias, as the polyclinics do not provide inpatient care

Appendix 5: Trial data

Table 5.1: Assessment of factors explaining health service use variation between trial arm.

Determinants of health service use	Data available on factors being compared	Expectation of difference	Actual difference	
			Cuba	Thailand
Patient factors				
Accessibility	Average distance from the clinic	NDE	NDO	NDO
	Average time from the clinic	NDE	NDO	NDO
	Availability or use of transport	NDE	NDO	SDO
	Average cost of transport	NDE	NDO	NDO
Cost of health services	Cost of consultation	VISIT	NDO	NDO
	Cost of medicines	VISIT	SDO	SDO
	Cost of food and drink	VISIT	NDO	SDO
	Relative cost to wage rate	VISIT	SDO	SDO
Opportunity cost	Waiting and treatment time	EXU	NDO	SDO
	Proportion of women with jobs	NDE	NDO	SDO
	Time taken off work	VISIT	NDO	SDO
	Paid leave to attend ANC	NDE	NDO	NDO
	Average salary	NDE	NDO	NDO
Use of alternative services	Alternatives available	NDE	NDO	NDO
	Amount of use of alternatives	EXU	NDO	NDO
Familiarity with modern health care	% first pregnancies	NDE	NDO	NDO
	Baseline average ANC visits	NDE	NDO	NDO
	% institutional delivery rates	NDE	NDO	NDO
Quality of care	% of women happy with service	EXU	SDO	SDO
	% women happy with spacing	EXU	SDO	SDO
Socio-economic status	Average age, marital status, number of years of education, average rooms per house	NDE	NDO	NDO
Cultural attitudes To services	Cultural acceptability of services	EXU	NDO	NDO
	Need for permission from family	NDE	NDO	NDO
Attitudes to risk	Desire for minimum ANC visits	NDE	NDO	NDO
Actual risk levels	Outcomes of previous pregnancy	NDE	SDO	SDO
		NDE	SDO	SDO
	Presence of other risk factors			
Morbidity levels	Presence of morbidity	EXU	SDO	SDO
Other	Weather patterns	NDE	NDO	NDO
Provider factors				
Financial incentives to providers	Fee schedule	NDE	NDO	NDO
	Other payments to providers	NDE	NDO	NDO
Compliance with standards of care	General contents of ANC	DE	SDO	SDO
	Monitoring systems in place	DE	SDO	SDO
Quality or effectiveness of health care staff	Training level of main providers	NDE	NDO	NDO
	Availability of diagnostic eq.	DE	SDO	SDO
	On-going refresher courses	NDE	NDO	NDO
Health care provider risk aversity	Norms for handling risk	DE	SDO	SDO
	Risk referral practices	DE	SDO	SDO
Capacity use facilities	Average % of capacity used	EXU	NDO	NDO

TABLE KEY: NDE – No Difference Expected; VISIT – Difference expected due to different numbers of visits, but not due to different cost per visit; EXU – Expected Difference Unknown; DE – Difference Expected; NDO – No Difference Observed; SDO – Some Difference Observed.

Table 5.2: Case-mix comparison between polyclinics and trial arm in Cuba.

PERIOD	VARIABLE	DATA	12	1	9	4	5	10	INT	7	11	6	3	8	2	CONT	ALL
Previous history	First pregnancy	%	0.20	0.17	0.21	0.16	0.21	0.18	0.19	0.16	0.19	0.16	0.18	0.19	0.19	0.18	0.18
	Previous stillbirth or neonatal loss	%	0.04	0.02	0.04	0.02	0.02	0.02	0.03	0.03	0.02	0.03	0.02	0.06	0.03	0.03	0.03
	>3 spontaneous abortions	%	0.84	0.89	0.83	0.84	0.86	0.79	0.84	0.86	0.85	0.83	0.87	0.86	0.87	0.86	0.85
	Previous low birth weight	%	0.01	0.01	0.07	0.02	0.02	0.05	0.03	0.05	0.05	0.05	0.06	0.07	0.03	0.05	0.04
	Previous birth outcome negative	%	0.75	0.78	0.77	0.74	0.72	0.70	0.75	0.76	0.75	0.69	0.75	0.80	0.74	0.75	0.75
	Hosp admission in last pregnancy	%	0.03	0.03	0.03	0.04	0.02	0.04	0.03	0.01	0.02	0.01	0.01	0.01	0.00	0.01	0.02
	Previous surgery on RT	%	0.03	0.03	0.06	0.05	0.03	0.05	0.04	0.01	0.01	0.03	0.01	0.03	0.01	0.01	0.03
Antenatal care	Gest age at 1st visit <12 weeks	%	0.78	0.82	0.81	0.84	0.84	0.83	0.82	0.83	0.88	0.83	0.86	0.86	0.86	0.86	0.84
	Gest age at 1st visit 12-15 weeks	%	0.18	0.14	0.14	0.12	0.11	0.13	0.14	0.14	0.10	0.13	0.10	0.10	0.11	0.11	0.12
	Gest age at 1st visit 16-19 weeks	%	0.02	0.02	0.03	0.03	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Gest age at 1st visit >20 weeks	%	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01
	Iron supplementation given	%	0.09	0.07	0.06	0.06	0.05	0.07	0.07	0.05	0.07	0.07	0.08	0.05	0.06	0.06	0.07
	Referred to higher level	%	0.16	0.15	0.16	0.14	0.14	0.13	0.15	0.13	0.15	0.07	0.11	0.12	0.12	0.12	0.14
	Hospital admission during AN	%	0.02	0.03	0.03	0.02	0.02	0.03	0.03	0.01	0.03	0.02	0.04	0.04	0.02	0.03	0.03
Events	Treated for syphilis	No.	20	51	131	46	39	36	323	47	28	18	84	45	50	272	595
	Treated for trichomoniasis	No.	9	21	11	17	11	16	85	11	6	3	14	5	5	44	129
	Treated for any STD	%	0.06	0.13	0.31	0.11	0.12	0.13	0.14	0.11	0.05	0.12	0.15	0.17	0.12	0.12	0.13
	Bleeding during pregnancy	%	0.34	0.35	0.31	0.40	0.36	0.37	0.36	0.39	0.36	0.34	0.42	0.48	0.39	0.40	0.38
	UTI - no treatment	No.	13	17	10	15	5	25	85	13	13	4	23	4	9	66	151
	UTI - with treatment	No.	6	6	6	12	13	6	49	9	9	3	18	6	6	51	100
	UTI cases (all)	%	0.04	0.04	0.03	0.05	0.04	0.08	0.05	0.04	0.04	0.04	0.06	0.03	0.03	0.04	0.04
Labour and Delivery	HDP cases (all)	%	0.08	0.08	0.08	0.08	0.07	0.08	0.08	0.06	0.09	0.06	0.08	0.08	0.07	0.08	0.08
	Breech presentation	%	0.03	0.03	0.04	0.03	0.02	0.02	0.03	0.03	0.02	0.03	0.05	0.04	0.04	0.04	0.03
	Adverse diagnosis at delivery	%	0.18	0.16	0.20	0.14	0.15	0.16	0.16	0.12	0.15	0.09	0.15	0.13	0.12	0.13	0.15
	Induced labour	%	0.18	0.20	0.18	0.17	0.19	0.17	0.18	0.17	0.18	0.13	0.20	0.19	0.16	0.18	0.18
	CS due to CPD	%	0.22	0.09	0.14	0.13	0.14	0.17	0.15	0.14	0.16	0.14	0.07	0.10	0.09	0.11	0.13
	CS due to previous CS	%	0.23	0.35	0.25	0.35	0.36	0.30	0.31	0.31	0.31	0.46	0.29	0.37	0.24	0.31	0.31
	CS due to breech position	%	0.10	0.12	0.13	0.10	0.10	0.10	0.11	0.13	0.08	0.11	0.15	0.12	0.17	0.13	0.12
Postpartum Outcomes	CS due to failure to progress	%	0.13	0.19	0.10	0.13	0.14	0.06	0.13	0.15	0.14	0.08	0.20	0.15	0.15	0.15	0.14
	CS due to fetal distress	%	0.22	0.17	0.28	0.15	0.18	0.20	0.20	0.18	0.22	0.14	0.25	0.24	0.27	0.23	0.21
	Neonate admitted to intensive care	%	0.06	0.05	0.08	0.05	0.06	0.05	0.06	0.05	0.07	0.07	0.04	0.05	0.06	0.06	0.06
	Postpartum syphilis test positive	No.	8	19	13	14	14	17	85	14	6	3	15	7	8	53	138
	Low birth weight	%	0.07	0.06	0.09	0.07	0.08	0.08	0.07	0.08	0.07	0.06	0.07	0.06	0.06	0.07	0.07

Table 5.3: Case-mix comparison between hospitals and trial arm in Thailand, and South Africa.

PERIOD	VARIABLE	DATA	1	3	4	6	11	12	INT	2	5	7	8	9	10	CONT	ALL	SA
Previous history	First pregnancy	%	0.41	0.38	0.44	0.49	0.36	0.37	0.41	0.38	0.40	0.43	0.39	0.42	0.42	0.40	0.41	0.36
	Previous stillbirth or neonatal loss	%	0.03	0.03	0.05	0.02	0.02	0.02	0.02	0.05	0.06	0.04	0.00	0.02	0.04	0.02	0.03	0.09
	>3 spontaneous abortions	%	0.22	0.24	0.33	0.30	0.27	0.21	0.15	0.29	0.29	0.23	0.21	0.21	0.30	0.15	0.26	0.11
	Previous low birth weight	%	0.09	0.09	0.08	0.10	0.09	0.06	0.05	0.05	0.07	0.09	0.17	0.07	0.13	0.05	0.09	0.24
	Previous birth outcome negative	%	0.26	0.24	0.26	0.29	0.24	0.15	0.15	0.29	0.28	0.27	0.38	0.18	0.29	0.16	0.26	0.19
Antenatal care	Previous surgery on RT	%	0.02	0.01	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.00	0.03	0.01	0.02	0.15
	Gest age at 1st visit <12 weeks	%	0.29	0.26	0.29	0.37	0.47	0.36	0.32	0.46	0.27	0.30	0.41	0.38	0.38	0.38	0.35	0.01
	Gest age at 1st visit 12-15 weeks	%	0.24	0.21	0.16	0.17	0.22	0.18	0.20	0.26	0.24	0.20	0.24	0.27	0.27	0.25	0.22	0.05
	Gest age at 1st visit 16-19 weeks	%	0.17	0.17	0.11	0.13	0.09	0.13	0.14	0.15	0.18	0.14	0.17	0.15	0.13	0.15	0.15	0.14
	Gest age at 1st visit >20 weeks	%	0.30	0.35	0.44	0.34	0.22	0.33	0.34	0.12	0.32	0.36	0.19	0.19	0.22	0.23	0.28	0.80
Events	Iron supplementation given	%	0.87	0.99	0.92	0.98	0.97	0.97	0.94	0.99	0.97	0.97	0.98	0.97	0.99	0.98	0.96	0.91
	Hospital admission during AN	%	0.03	0.02	0.03	0.03	0.05	0.02	0.03	0.03	0.02	0.03	0.01	0.01	0.10	0.03	0.03	0.32
	Treated for syphilis	No.	5	3	2	0	0	0	10	0	2	1	0	0	1	4	14	80
	Treated for trichomoniasis	No.	140	7	21	24	13	3	208	2	1	3	1	0	2	9	217	130
	Treated for any STD	%	0.15	0.02	0.05	0.06	0.05	0.02	0.08	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.04	0.27
	Bleeding during pregnancy	%	0.01	0.03	0.04	0.05	0.04	0.03	0.03	0.01	0.02	0.01	0.01	0.00	0.03	0.01	0.02	0.02
	UTI - no treatment	No.	1	18	10	3	5	1	38	2	30	3	0	1	2	38	76	18
	UTI - with treatment	No.	9	6	12	17	9	3	56	12	3	4	2	0	7	28	84	119
	UTI cases (all)	%	0.01	0.03	0.04	0.04	0.05	0.02	0.03	0.02	0.10	0.01	0.01	0.00	0.03	0.02	0.03	0.17
	HDP cases (all)	%	0.01	0.01	0.01	0.01	0.02	0.01	0.00	0.01	0.02	0.06	0.01	0.01	0.01	0.01	0.01	0.11
Labour and Delivery	Breech presentation	%	0.03	0.02	0.03	0.02	0.03	0.03	0.03	0.02	0.02	0.01	0.02	0.01	0.02	0.02	0.02	0.03
	Adverse diagnosis at delivery	%	0.04	0.05	0.07	0.07	0.07	0.05	0.06	0.09	0.04	0.06	0.01	0.02	0.06	0.05	0.05	0.28
	Induced labour	%	0.04	0.02	0.07	0.03	0.02	0.05	0.04	0.06	0.03	0.08	0.02	0.00	0.03	0.04	0.034	0.06
	CS due to CPD	%	0.36	0.22	0.26	0.45	0.22	0.13	0.02	0.33	0.43	0.36	0.19	0.36	0.18	0.02	0.30	0.16
	CS due to previous CS	%	0.22	0.30	0.31	0.05	0.33	0.38	0.02	0.30	0.21	0.18	0.29	0.09	0.27	0.01	0.25	0.31
	CS due to breech position	%	0.22	0.13	0.24	0.18	0.11	0.00	0.01	0.17	0.07	0.14	0.19	0.09	0.18	0.01	0.17	0.12
	CS due to failure to progress	%	0.16	0.17	0.14	0.09	0.11	0.25	0.01	0.26	0.29	0.11	0.10	0.18	0.23	0.01	0.17	0.33
	CS due to fetal distress	%	0.11	0.09	0.03	0.18	0.11	0.00	0.01	0.15	0.14	0.36	0.10	0.09	0.14	0.01	0.13	0.41
Postpartum Outcomes	Neonate admitted to intensive care	%	0.06	0.05	0.02	0.03	0.03	0.03	0.04	0.02	0.07	0.04	0.04	0.01	0.06	0.03	0.04	0.71
	Postpartum syphilis test positive	No.	4	3	3	1	0	0	11	3	3	4	0	1	1	12	23	33
	Low birth weight	%	0.09	0.09	0.09	0.11	0.09	0.11	0.09	0.09	0.09	0.08	0.05	0.09	0.07	0.08	0.09	n/a

KEY: INT – Intervention arm; CONT – Control arm; ALL – Intervention plus control arms; SA – South Africa; Gest – Gestational age; CPD – Cephalo-pelvic disproportion; CS – Caesarean section; UTI – Urinary tract infection; HDP – Hypertensive disorders of pregnancy; STD – Sexually transmitted disease.

Table 5.4: Health service use data by health facility, trial arm, and country.

Country and health care provider	Number of cases	Outpatient ANC		Inpatient ANC							Deliveries		Postpartum stay				Neonatal ICU			
		Average visits		Cases		Mean LOS			Med LOS		Percentage		Mean LOS		Median LOS		Cases	Neonate LOS		
		Mean	Med	LR	HR	LR	HR	ALL	LR	HR	VD	CS	VD	CS	VD	CS	No.	Mean	Med	ALL
CUBA																				
13 de Marzo	450	7.5	6	42	30	16.3	10.5	2.22	7	6	77	23	3.0	6.8	2	5	24	11.5	8	0.61
Albarran	567	7.8	6	69	21	10.6	14.0	1.81	7	6	82	18	3.3	5.5	2	5	27	14.4	9	0.69
Galvan	459	7.3	5	60	14	17.3	9.5	2.56	9	7	74	26	3.8	6.3	2	5	39	13.8	10	1.17
Manduley	576	7.6	5	53	31	12.2	11.7	1.76	9	8	75	25	2.9	5.7	2	5	27	10.4	6	0.49
Romay	418	7.4	5	47	15	15.6	11.3	2.15	9	7	76	24	3.1	6.2	2	5	25	12.6	8	0.75
Zuluetta	402	7.3	5	43	11	10.1	5.9	1.24	7	4	79	21	3.3	5.6	3	5	22	7.7	6.5	0.42
<i>Average intervention</i>	<i>2872</i>	<i>7.50</i>	<i>6</i>	<i>314</i>	<i>122</i>	<i>13.61</i>	<i>10.92</i>	<i>1.95</i>	<i>8</i>	<i>6</i>	<i>77.4</i>	<i>22.6</i>	<i>3.22</i>	<i>6.03</i>	<i>2</i>	<i>5</i>	<i>164</i>	<i>12.0</i>	<i>8</i>	<i>0.7</i>
Aballi	514	13.3	13	53	17	14.9	7.1	1.77	9	6	77	23	3.1	6.0	2	5	29	9.8	9	0.55
Escalona	628	13.0	12	69	28	15.0	6.7	1.93	9	5	76	24	3.2	5.7	2	5	46	11.0	6	0.81
Guiteras	178	12.4	12	10	3	14.1	8.7	0.94	10	6	79	21	3.3	5.2	2	5	12	9.6	6	0.65
Reina	648	13.0	13	56	19	11.3	11.7	1.32	9	10	76	24	2.9	5.5	2	5	27	10.1	7	0.42
Tamayo	296	13.6	13	32	5	8.5	8.4	1.06	8	7	77	23	2.9	6.0	2	5	16	14.1	6.5	0.76
Vantroi	473	13.1	13	46	12	13.3	8.0	1.50	9	8	77	23	3.1	6.4	2	5	30	10.2	10	0.65
<i>Average control</i>	<i>2737</i>	<i>13.14</i>	<i>13</i>	<i>266</i>	<i>84</i>	<i>13.07</i>	<i>8.25</i>	<i>1.53</i>	<i>9</i>	<i>6</i>	<i>76.6</i>	<i>23.4</i>	<i>3.04</i>	<i>5.82</i>	<i>2</i>	<i>5</i>	<i>160</i>	<i>10.68</i>	<i>7</i>	<i>0.6</i>
THAILAND																				
Chumpae	1001	4.05	4	30		2.5		0.075	2		94	6	2.11	3.96	2	4.0	62	4.79	3	0.30
Banphai	729	4.58	4	7		2.0		0.019	1		91	9	1.79	3.83	2	4.0	36	11.89	3	0.59
Phuwiang	558	4.74	4	14		3.4		0.086	3		87	3	1.40	2.26	1	3.0	8	7.88	6	0.11
Manjakiri	476	4.43	4	16		2.9		0.099	2		95	5	1.53	2.48	1	3.0	16	3.94	3	0.13
Khaosuankwang	306	4.24	4	12		4.0		0.157	2		97	3	1.69	2.05	2	0.0	9	2.78	2	0.08
Waeng Noi	208	4.47	4	8		2.3		0.087	2		95	5	1.95	1.53	2	1.0	6	6.17	5	0.18
<i>Intervention average</i>	<i>3278</i>	<i>4.38</i>	<i>4</i>	<i>87</i>		<i>2.87</i>		<i>.073</i>	<i>2</i>		<i>93.0</i>	<i>7.0</i>	<i>1.78</i>	<i>3.00</i>	<i>2</i>	<i>4</i>	<i>137</i>	<i>7.44</i>	<i>3</i>	<i>0.28</i>
Kranuan	821	6.56	7	34		3.4		0.141	2		93	7	1.50	4.95	1	6.0	19	5.16	3	0.12
Nongsonghong	323	6.19	6	4		1.8		0.022	1		96	4	1.73	3.32	2	3.5	21	5.14	3	0.33
Phol	630	8.11	8	16		4.2		0.106	3		93	7	1.92	3.70	2	4.0	25	12.68	4	0.50
Nongrua	400	6.37	6	2		2.0		0.010	2		95	5	1.43	4.65	1	6.0	15	3.40	2	0.13
Srichompoo	595	7.10	7	1		3.0		0.005	3		98	2	1.03	0.23	1	0.0	8	6.75	5	0.09
Nampong	322	8.42	9	24		2.6		0.193	2		93	7	1.49	2.85	1	3.0	18	8.94	3	0.50
<i>Control average</i>	<i>3091</i>	<i>7.11</i>	<i>7</i>	<i>91</i>		<i>3.19</i>		<i>0.085</i>	<i>2</i>		<i>95.0</i>	<i>5.0</i>	<i>1.64</i>	<i>2.26</i>	<i>1</i>	<i>3</i>	<i>106</i>	<i>6.60</i>	<i>3</i>	<i>0.25</i>
SOUTH AFRICA																				
Prince Mshiyeni	785	5.97	6	249		6.9		2.330	3		0.78	0.22	2.21	7.33	1	7.0	423	3.13	1	1.69

TABLE KEY: LOS – length of stay; HR – high risk woman; LR – low risk woman; VD – vaginal delivery; CS – cesareran section; med. – median; ALL – all cases.

Figure 5.1: Distribution of numbers of ANC visits in intervention arm in Cuba

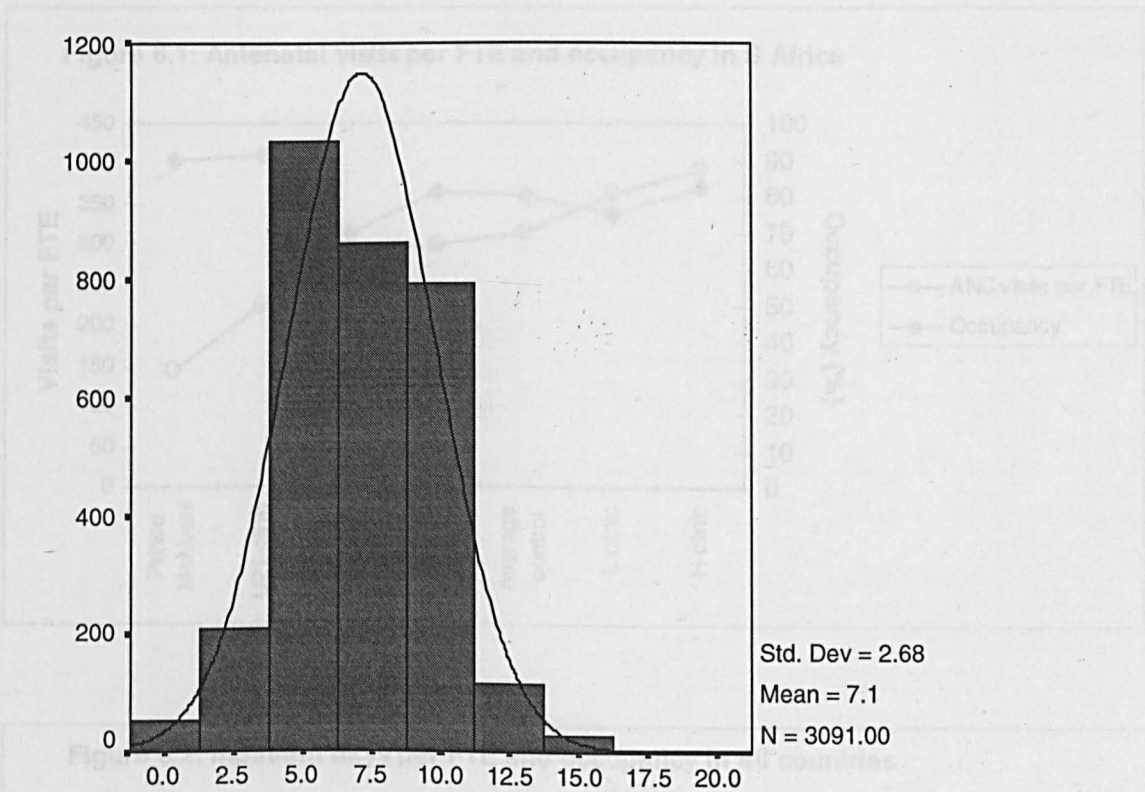
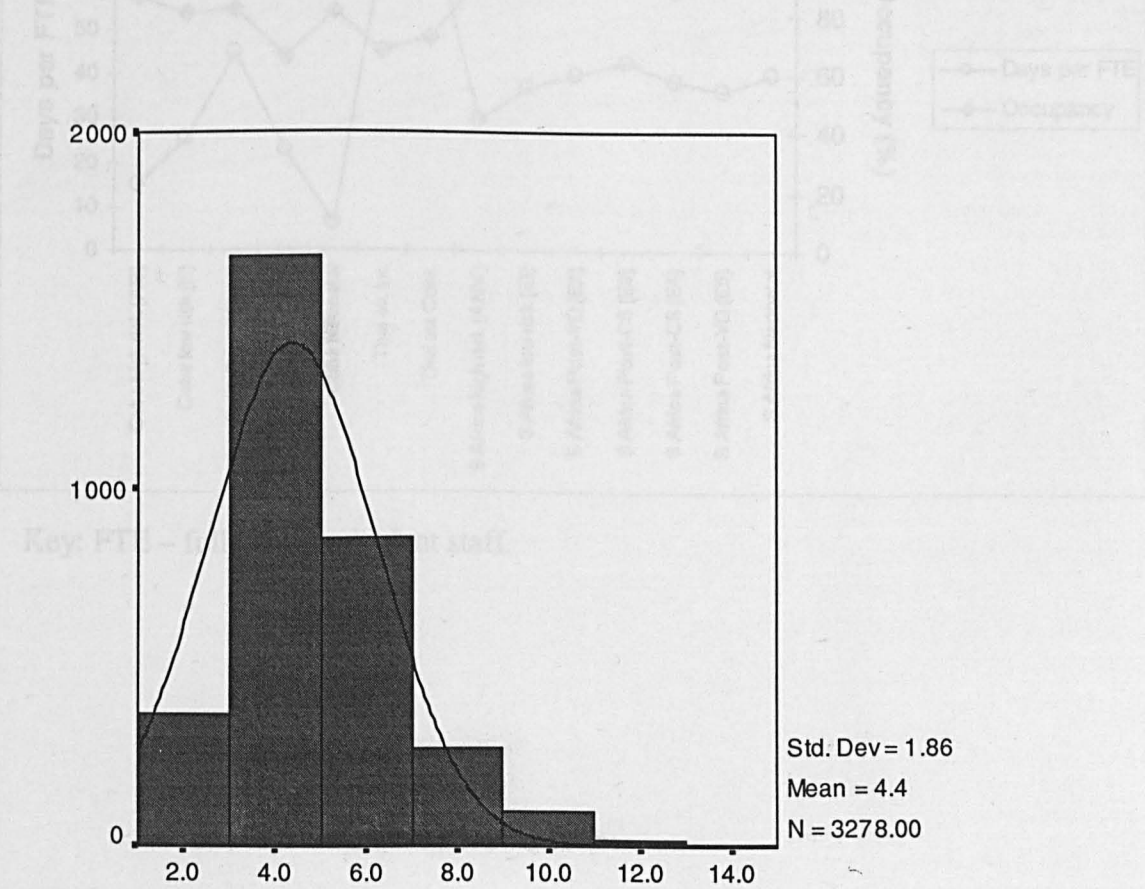


Figure 5.2: Distribution of numbers of ANC visits in intervention arm in Thailand



Appendix 6: Staff productivity

Figure 6.1: Antenatal visits per FTE and occupancy in S Africa

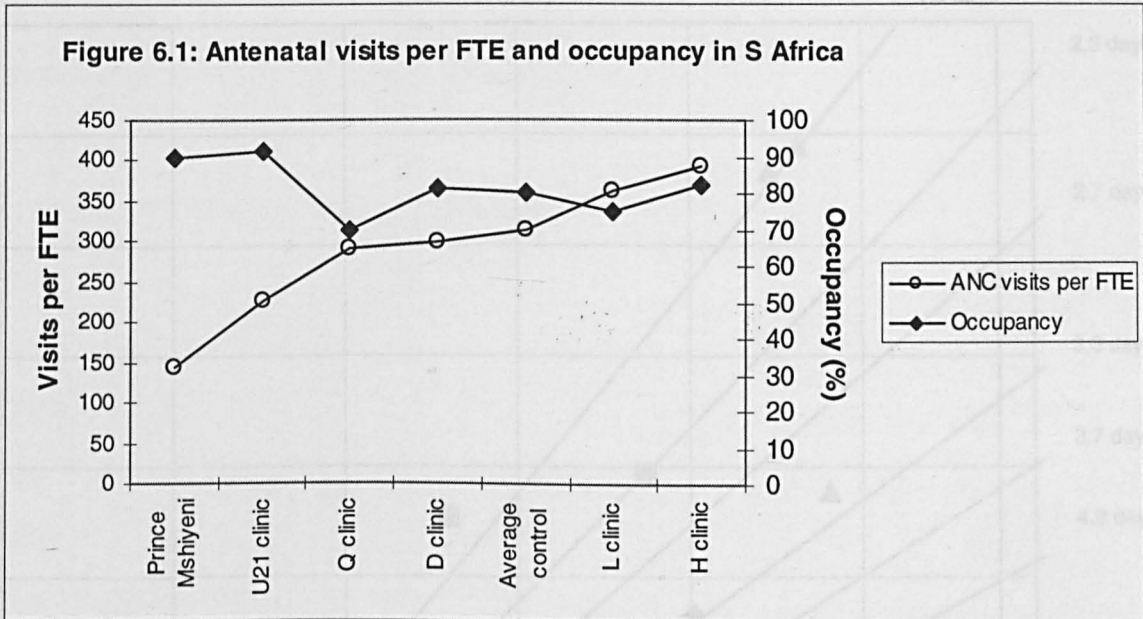
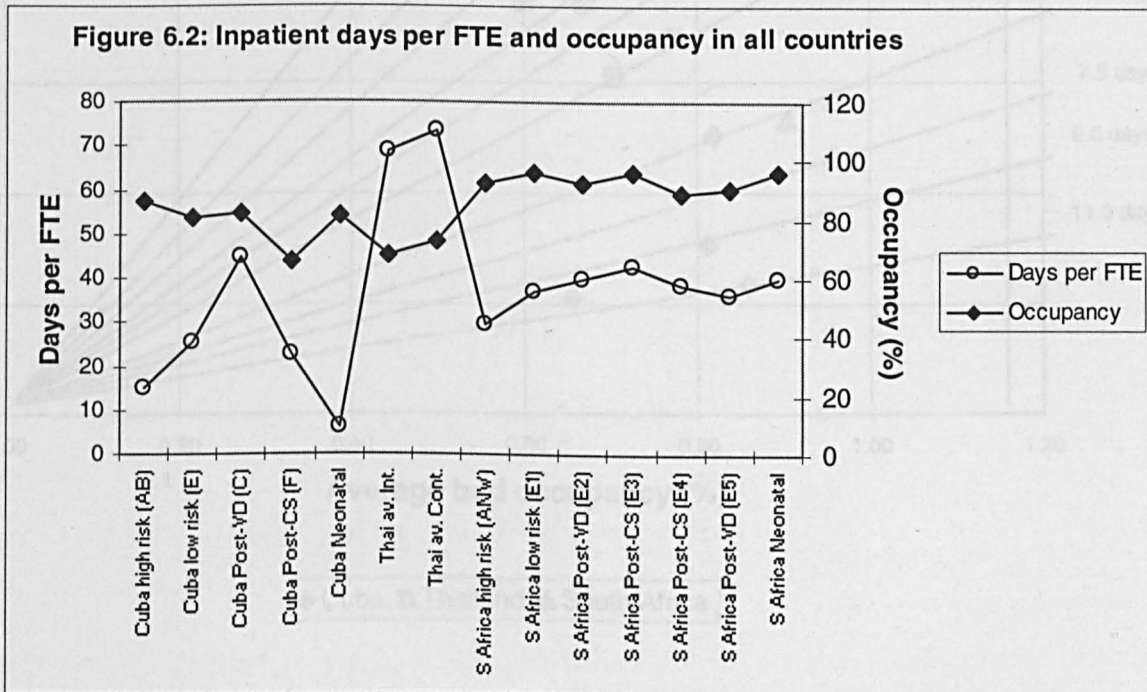
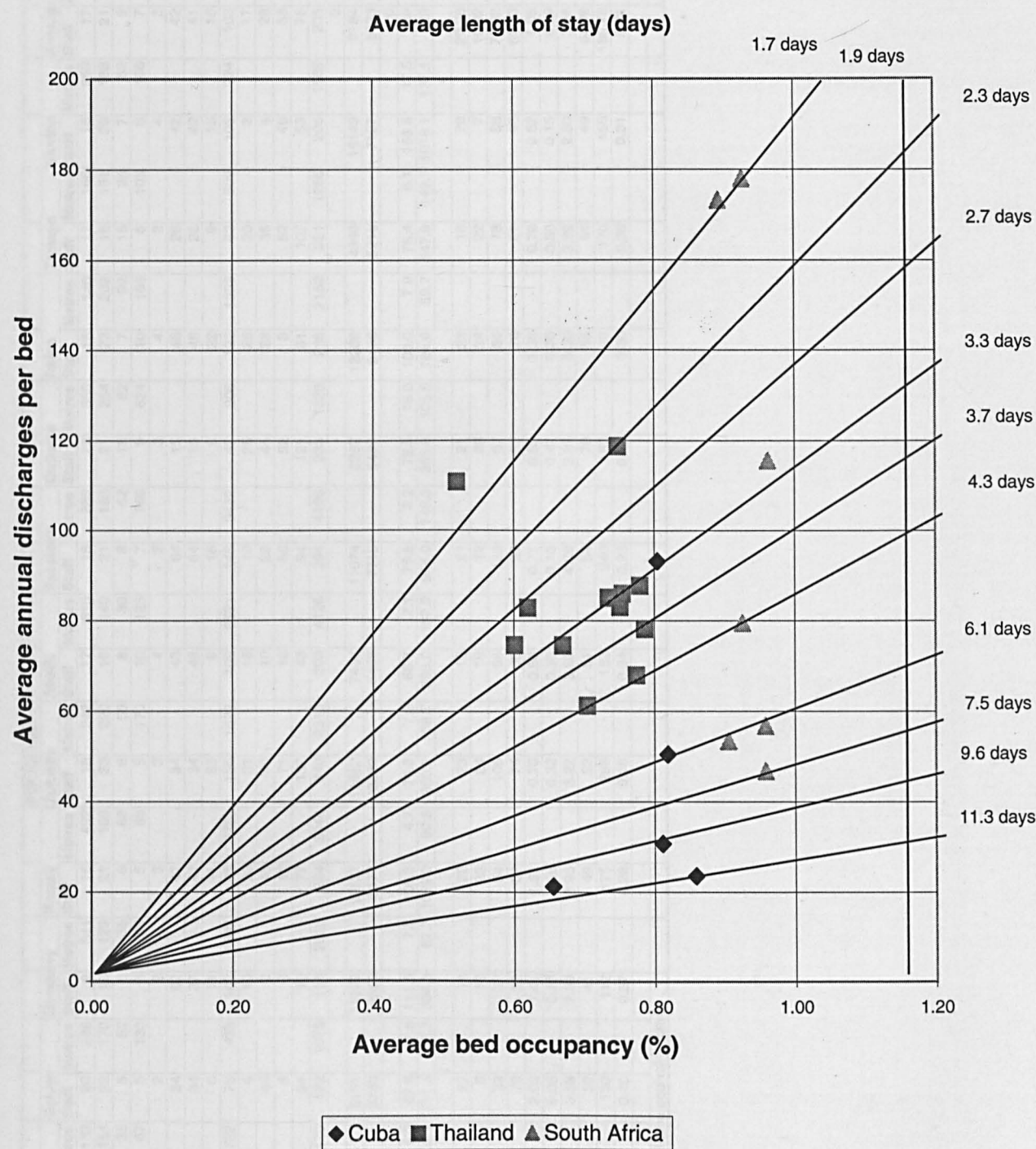


Figure 6.2: Inpatient days per FTE and occupancy in all countries



Key: FTE – full-time equivalent staff.

Figure 6.3: Occupancy, average discharges per bed, and average length of stay ('Lasso' graph).



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DEPARTMENT	STAFF																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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Table 6.2: Staff, building space, and health service output in Thai hospitals.

DEPARTMENT	STAFF	HEALTH CARE PROVIDER UNIT																								Average	
GROUPING	TYPE	Chumpae		Banphai		Puweng		Manjakiri		Khaosankuang		Waengnoi		Kranuan		Nongsonghong		Phon		Nongrua		Sichompoo		Nampong		Staff	Metres
Raw Data		Staff	Metres	Staff	Metres	Staff	Metres	Staff	Metres	Staff	Metres	Staff	Metres	Staff	Metres	Staff	Metres	Staff	Metres	Staff	Metres	Staff	Metres	Staff	Metres	Staff	Metres
Service	Non-health	27	1807	17	810	11	507	11	222	8	805	13	477	21	164	37	206	28	615	14	525	4	108	28	573	18	568
Admin	Non-health	9	240	15	182	6	30	7	390	4	72	4	227	7	308	10	208	7	168	5	136	4	516	11	138	7	218
Lab	Non-health	10	49	5	40	5	24	5	32	2	24	2	16	6	24	2	24	6	80	4	20	3	30	6	40	5	34
Support	Non-health	46	780	19	545	12	360	22	378	7	398	12	386	21	670	14	644	20	394	12	687	17	166	14	850	18	522
Other	Non-health	7	116	4	20	8	28	4	72	3	0	2	35	5	64	4	68	8	50	7	75	4	20	10	155	6	59
Outpatient	Nurse	4		3		3		2		3		4		3		4		4		5		4		5		4	
	Non-health	4		2		2		3		4		0		3		1		0		2		9		5		3	
	TOTAL	8	80	5	434	5	213	5	110	7	117	4	38	6	56	5	104	4	52	7	297	13	73	10	120	7	141
Inpatient	Doctor	1		1		2		1		1		1		2		1		1		1		1		1		1	
	Nurse	20		27		21		16		13		11		31		10		20		18		14		19		18	
	Non-health	16		12		3		12		1		6		16		6		18		6		7		10		9	
	TOTAL	37	2200	40	1546	26	665	29	379	15	726	18	525	49	3200	17	362	39	1084	25	713	22	532	30	980	29	1076
Labour	Nurse	2		10		1		5		2		1		9		5		4		10		4		6		5	
	Non-health	0		7		2		1		1		1		4		1		2		3		0		5		2	
	TOTAL	2	21	17	40	3	27	6	50	3	25	2	68	13	140	6	73	6	77	13	36	4	64	11	60	7	57
Surgery	Nurse	16		4		3		3		1		1		5		1		6		0		2		6		4	
	Non-health	14		1		1		1		1		1		2		1		2		0		1		0		2	
	TOTAL	30	184	5	100	4	27	4	108	2	25	2	56	7	162	2	48	8	127	0	49	3	100	6	90	6	90
Other	Doctor	6		4		2		2		3		1		2		3		5		3		2		5		3	
	Nurse	16		13		9		14		5		10		14		10		16		12		2		14		11	
	Non-health	26		32		13		15		13		13		21		14		18		15		15		23		18	
	TOTAL	48	900	49	605	24	386	31	484	21	392	24	268	37	572	27	540	39	684	30	396	19	488	42	255	33	498
		224	6377	176	4322	104	2267	124	2225	72	2584	83	2096	172	5360	124	2277	165	3331	117	2934	93	2097	168	3261	135	3261
Average throughput																											
Average OPV/month		303		208		200		171		96		51		270		151		115		313		162		219		188	0
Average IPD/month		5378		1846		1674		1622		522		864		2382		1180		2249		421		1194		1938		1773	0
Average IPA/month		3147		574		728		494		191		210		760		322		755		138		361		598		690	0
Average NVD/month		157		116		137		67		24		14		240		82		62		72		59		96		94	0
Average surgery/month		110		60		176		22		60		4		3026		19		12		23.5		27.5		622		347	0
Average lab tests/month		3540		3032		4083		1494		610		1060		1580		1380		98		1725		1234		298		1678	0
Average NN days/month		236		242		0		138		0		26		305		170		3959		0		107		170		446	0
Input/output ratios																											
OPV per FTE/metre*		94.7	9.5	104.0	1.2	100.0	2.3	85.5	3.9	34.3	2.1	63.8	6.7	112.5	12.1	151.0	7.3	71.9	5.5	111.8	2.6	62.3	11.1	54.8	4.6	87.2	5.7
IPD per FTE/metre		151.7	2.4	52.2	1.2	64.4	2.5	60.7	4.3	34.8	0.7	49.4	1.6	54.8	0.7	79.4	3.3	159.2	2.1	16.8	0.6	59.1	2.2	70.3	2.0	71.1	2.0
IPA per FTE/metre		85.1	1.4	14.4	0.4	28.0	1.1	17.0	1.3	12.7	0.3	11.7	0.4	15.5	0.2	18.9	0.9	19.4	0.7	5.5	0.2	16.4	0.7	19.9	0.6	22.0	0.7
DEL per FTE/metre		78.5	7.5	6.8	2.9	45.7	5.1	11.2	1.3	8.0	1.0	7.0	0.2	18.5	1.7	13.7	1.1	10.3	0.8	5.5	2.0	14.8	0.9	8.7	1.6	19.1	2.2
SURG per FTE/metre		3.7	0.6	12.0	0.6	44.0	6.5	5.5	0.2	30.0	2.4	2.0	0.1	432.3	18.7	9.5	0.4	1.5	0.1	0.0	0.5	9.2	0.3	103.7	6.9	59.4	3.1
LAB per FTE/metre		354.0	72.2	606.4	75.8	816.6	170.1	298.8	46.7	305.0	25.4	530.0	66.3	263.3	65.8	690.0	57.5	16.3	1.2	431.3	86.3	411.3	41.1	49.7	7.5	397.7	59.7
Staff ratios																											
Admin worker		9		15		6		7		4		4		7		10		7		5		4		11		7.42	
Specialist		0		0		0		0		0		0		0		0		0		0		0		0		0.00	
Nurse		58		57		37		40		24		27		62		30		50		45		26		50		42.17	
Doctor		7		5		4		3		4		2		4		4		6		4		3		6		4.33	
Nurse/doctor		0.12		0.09		0.11		0.08		0.17		0.07		0.06		0.13		0.12		0.09		0.12		0.12		0.11	
Doctor/specialist		0		0		0		0		0		0		0		0		0		0		0		0		0.00	
Doctor/admin worker		0.78		0.33		0.67		0.43		1.00		0.50		0.57		0.40		0.86		0.80		0.75		0.55		0.64	
Overhead staff		99		60		42		49		24		33		60		67		69		42		32		69			
Health care staff		125		116		62		75		48		50		112		57		96		75		61		99			
Ratio overhead/health care		0.79		0.52		0.68		0.65		0.50		0.66		0.54		1.18		0.72		0.56		0.52		0.70			
																										6.27	
*Note: Waengnoi, Sichompoo and Nongsonghong operate the Health Promotion Unit only 1 days a week for ANC instead of the usual 2 days a week																											
Table key: OPV - outpatient visits; IPD/A - Inpatient days/admissions; LAB - laboratory tests; FTE - Full-time equivalent staff; DEL - Number of deliveries; SURG - Number of operations																											

*Note: Waengnoi, Sichompoo and Nongsonghong operate the Health Promotion Unit only 1 days a week for ANC instead of the usual 2 days a week

Table key: OPV - outpatient visits; IPD/A - Inpatient days/admissions; LAB - laboratory tests; FTE - Full-time equivalent staff; DEL - Number of deliveries; SURG - Number of operations

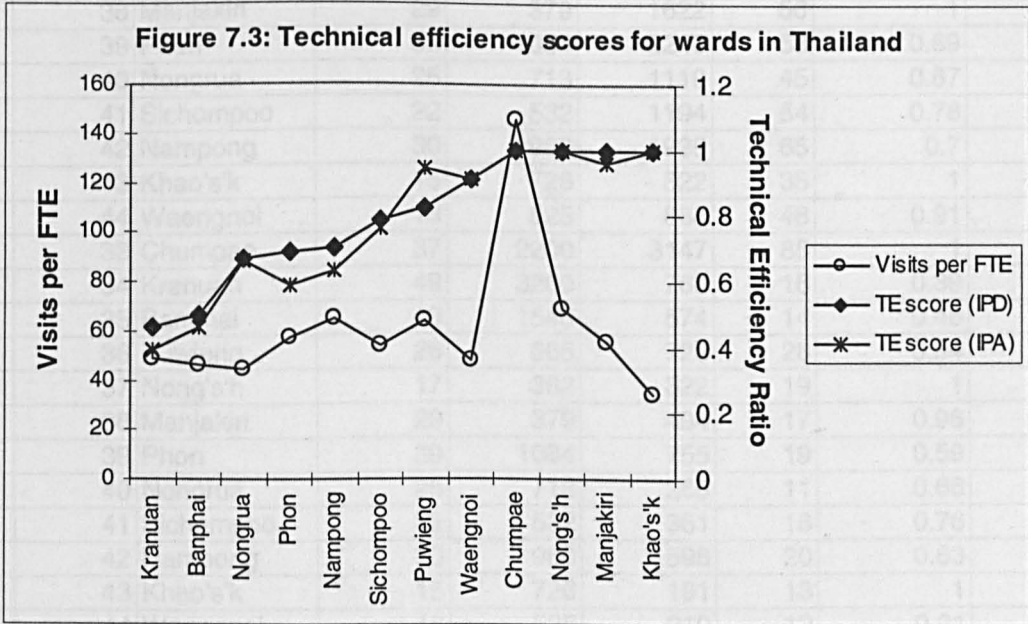
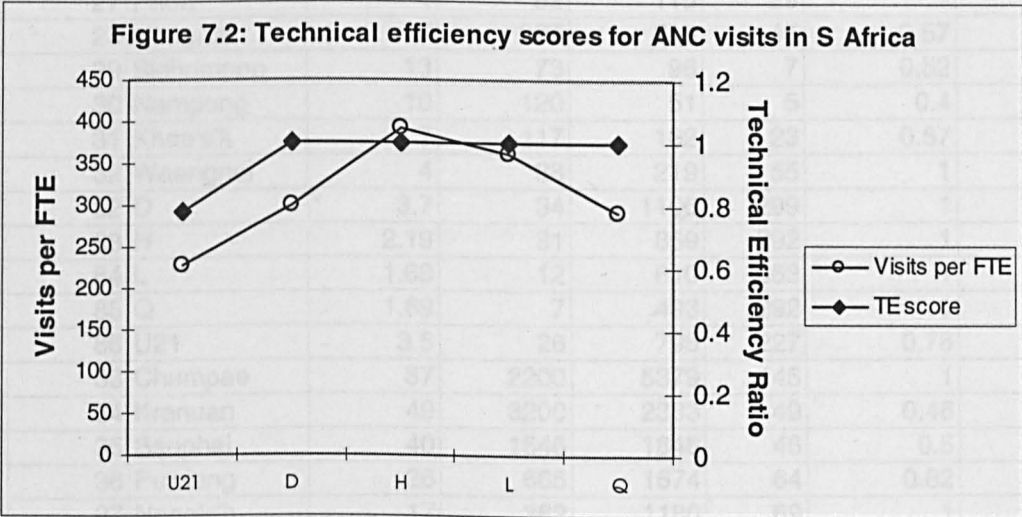
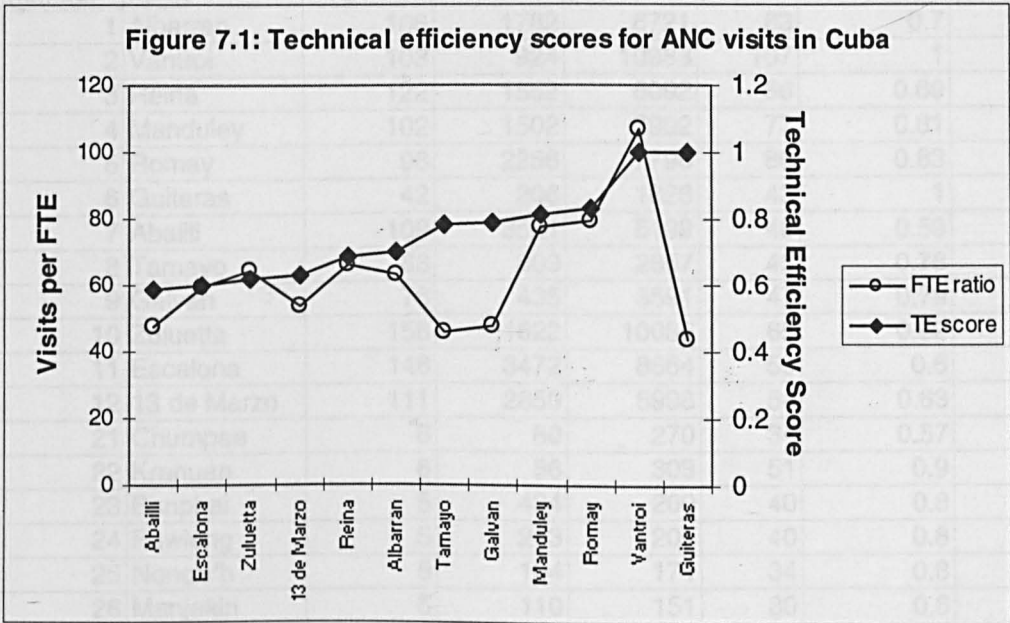
Table 6.3: Staff, space and output in clinics in South Africa

VARIABLE	D clinic			H clinic			L clinic			Q clinic			U21 clinic		
	No.	ANC rate*	All rate**	No.	ANC rate*	All rate**	No.	ANC rate*	All rate**	No.	ANC rate*	All rate**	No.	ANC rate*	All rate**
Staff															
Nurse	19		293.16	16		390.88	16		365.31	18		295.39	26		238.35
Nurse ANC	3.7	298.92		2.19	392.24		1.68	363.10		1.69	291.72		3.5	227.43	
Non-health	9			12			10			9			14		
TOTAL	28	39.50	198.93	28	30.68	223.36	26	23.46	224.81	27	18.26	196.93	40	19.90	154.93
RATIO	0.47			0.75			0.63			0.5			0.54		
Space															
General rooms	311		17.91	208		30.07	185		31.59	194		27.41	348		17.81
AN consult.	34	81.32		31	69.27		12	127.08		7	176.07		26	76.54	
Maternity ward	62			64			18			24			78		
Other space	65			52			21			23			28		
TOTAL	472		11.80	355		17.62	236		24.77	248		21.44	480		12.91
Output															
ANC OPV	1106			859			610			493			796		
Total OPV	5570			6254			5845			5317			6197		
* ANC rate = ANC OPV / ANC staff; ** All rate = OPV / staff															
Table key: ANC - Antenatal care; OPV - outpatient visits.															

Table 6.4: Staff, building space, and health service output from referral hospitals in Cuba and South Africa.

Country & cost centre	Specialist	Doctor	Staff Nurse	Non-health	Total	Square metres	Output OPV	Output IPD	Output CASES	Output per staff	Output per sq.m
Cuba (America Arias hospital)											
Services	0	0	0	43	43	350	0	0	0	n/a	n/a
Administration	0	0	0	55	55	446	0	0	0	n/a	n/a
Laboratory	0	0	0	69	69	760	0	0	0	n/a	n/a
Support	0	0	0	98	98	603	0	0	0	n/a	n/a
OP department	3	0	7	2	12	535	3404	0	0	283.7	6.4
AB ward	6	0	10	3	19	211	0	290	0	15.3	1.4
C ward	5	0	9	5	19	327	0	848	0	44.6	2.6
E ward	10.5	0	8	2	20.5	223	0	520	0	25.4	2.3
F ward	3.7	0	7	4	14.7	272	0	334	0	22.7	1.2
Labour room	1	0	14	6	21	313	0	0	725	34.5	2.3
Neonatal room	11.1	0	38	4	53.1	325	0	313	0	5.9	1.0
Operating theatre	7.5	0	24	2	33.5	290	0	0	220	6.6	0.8
Other	0	0	0	0	0	4917	0	0	0	n/a	n/a
TOTAL	47.8	0	117	293	457.8	9572	3404	2305	945	n/a	n/a
South Africa (Prince Mshiyeni hospital)											
Services	0	0	0	119	119	1405	0	0	0	n/a	n/a
Administration	0	0	0	24	24	8250	0	0	0	n/a	n/a
Laboratory	0	0	0	36	36	1610	0	0	0	n/a	n/a
Support	0	0	0	74	74	7688	0	0	0	n/a	n/a
OP department	0	0	12	4	16	980	2295	0	0	143.4	2.3
ANW ward	1	3	19	4	27	300	0	797	0	29.5	2.7
E1 ward	1	2	15	4	22	468	0	815	0	37.0	1.7
E2 ward	1	2	5	4	12	468	0	881	0	73.4	1.9
E3 ward	1	2	17	4	24	468	0	1028	0	42.8	2.2
E4 ward	1	2	18	4	25	468	0	970	0	38.8	2.1
E5 ward	1	2	15	4	22	468	0	798	0	36.3	1.7
Labour room	1	4	36	17	58	1200	0	0	870	15.0	0.7
Neonatal room	37	4	41	0	82	1000	0	1643	0	20.0	1.6
Operating theatre	0	8	12	0	20	440	0	0	300	15	1
Other	n/a	n/a	n/a	n/a	1042	35528	n/a	n/a	n/a	n/a	n/a
TOTAL	44	29	190	298	1603	60741	2295	6932	1170	n/a	n/a
Table key: OPV - outpatient visits; IPD - Inpatient days; CASES - Number of operations or deliveries											

Appendix 7: Technical efficiency scores from data envelopment analysis



Key:TE – technical efficiency; IPD – inpatient days; IPA – inpatient admissions.

Table 7.1: Input data, output data, and technical efficiency results from the resource use DEA model.

Country	Provider number	Provider name	Staff FTE	Square metres	Through-put	FTE ratio	TE score (VRS)	TE score (CRS)
Cuba ANC	1	Albarran	106	1782	6721	63	0.7	0.59
	2	Vantroi	103	924	10983	107	1	1
	3	Reina	122	1552	8092	66	0.69	0.62
	4	Manduley	102	1502	7902	77	0.81	0.73
	5	Romay	98	2256	7796	80	0.83	0.75
	6	Guiteras	42	206	1826	43	1	0.75
	7	Abailli	109	3521	5199	48	0.59	0.45
	8	Tamayo	63	809	2857	45	0.78	0.43
	9	Galvan	76	435	3591	47	0.79	0.69
	10	Zuluetta	156	1622	10085	65	0.62	0.61
	11	Escalona	146	3472	8664	59	0.6	0.56
	12	13 de Marzo	111	2850	5998	54	0.63	0.51
Thai ANC	21	Chumpae	8	80	270	34	0.57	0.56
	22	Kranuan	6	56	303	51	0.9	0.9
	23	Banphai	5	434	200	40	0.8	0.51
	24	Puwieng	5	213	201	40	0.8	0.51
	25	Nong's'h	5	104	171	34	0.8	0.44
	26	Manjakiri	5	110	151	30	0.8	0.39
	27	Phon	4	52	115	29	1	1
	28	Nongrua	7	297	313	45	0.57	0.57
	29	Sichompoo	13	73	96	7	0.52	0.22
	30	Nampong	10	120	51	5	0.4	0.07
	31	Khao's'k	7	117	162	23	0.57	0.3
	32	Waengnoi	4	38	219	55	1	0.96
S Africa ANC	82	D	3.7	34	1106	299	1	0.8
	83	H	2.19	31	859	392	1	1
	84	L	1.68	12	610	363	1	1
	85	Q	1.69	7	493	292	1	1
	86	U21	3.5	26	796	227	0.78	0.62
Thai IPD	33	Chumpae	37	2200	5379	145	1	1
	34	Kranuan	49	3200	2383	49	0.46	0.33
	35	Banphai	40	1546	1846	46	0.5	0.44
	36	Puwieng	26	665	1674	64	0.82	0.8
	37	Nong's'h	17	362	1180	69	1	0.97
	38	Manjakiri	29	379	1622	56	1	1
	39	Phon	39	1084	2249	58	0.69	0.68
	40	Nongrua	25	713	1119	45	0.67	0.52
	41	Sichompoo	22	532	1194	54	0.78	0.7
	42	Nampong	30	980	1939	65	0.7	0.69
	43	Khao's'k	15	726	522	35	1	0.28
	44	Waengnoi	18	525	864	48	0.91	0.55
Thai IPA	33	Chumpae	37	2200	3147	85	1	1
	34	Kranuan	49	3200	760	16	0.39	0.18
	35	Banphai	40	1546	574	14	0.46	0.26
	36	Puwieng	26	665	728	28	0.94	0.77
	37	Nong's'h	17	362	322	19	1	0.62
	38	Manjakiri	29	379	494	17	0.96	0.12
	39	Phon	39	1084	755	19	0.59	0.49
	40	Nongrua	25	713	266	11	0.66	0.26
	41	Sichompoo	22	532	361	16	0.76	0.08
	42	Nampong	30	980	598	20	0.63	0.43
	43	Khao's'k	15	726	191	13	1	0.18
	44	Waengnoi	18	525	210	12	0.91	0.28

Appendix 8: Unit cost determinants

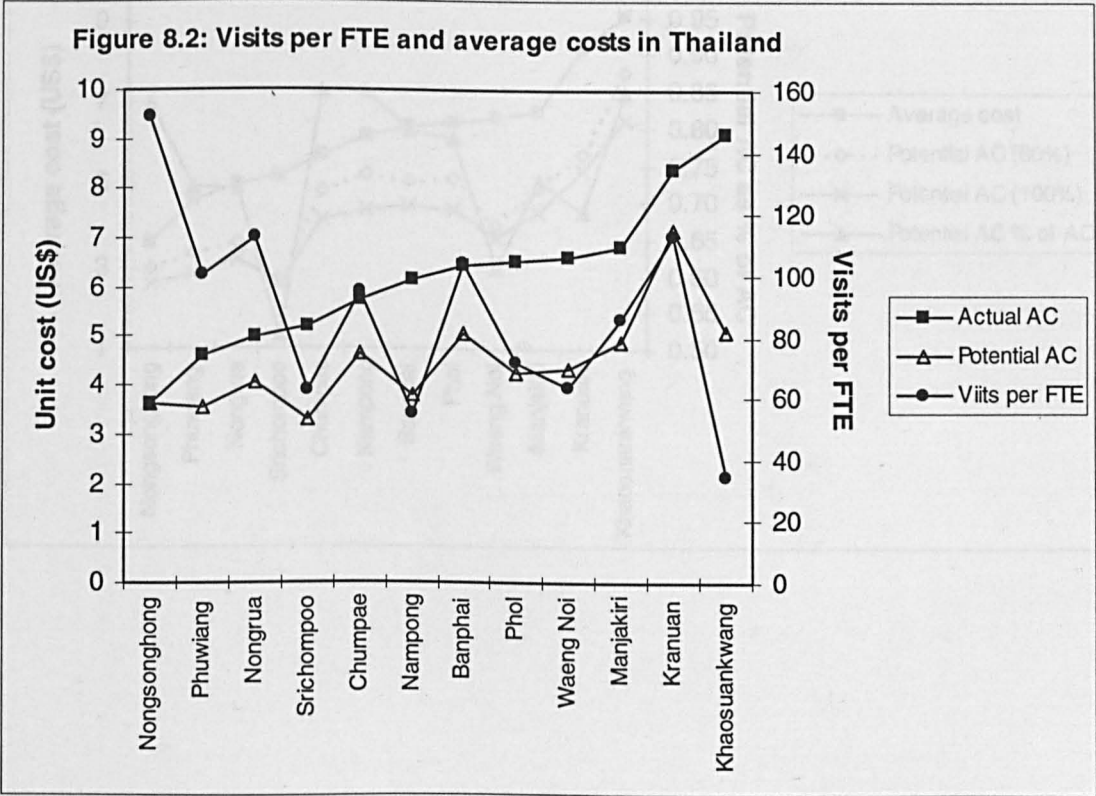
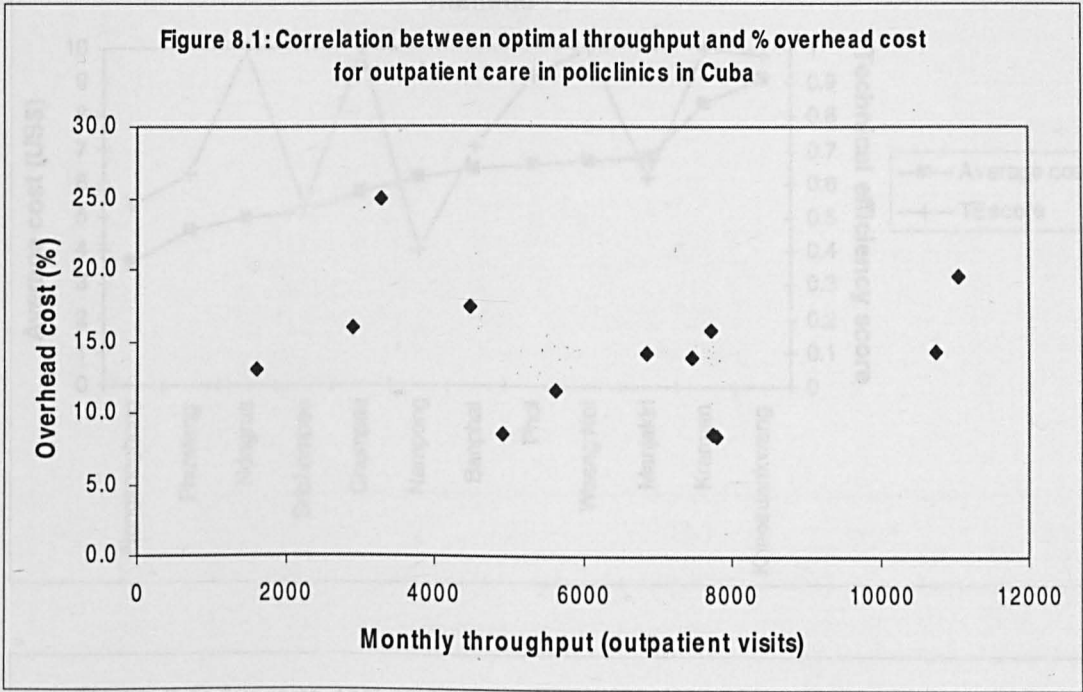


Figure 8.3: Average costs and TE scores for outpatient care in Thailand

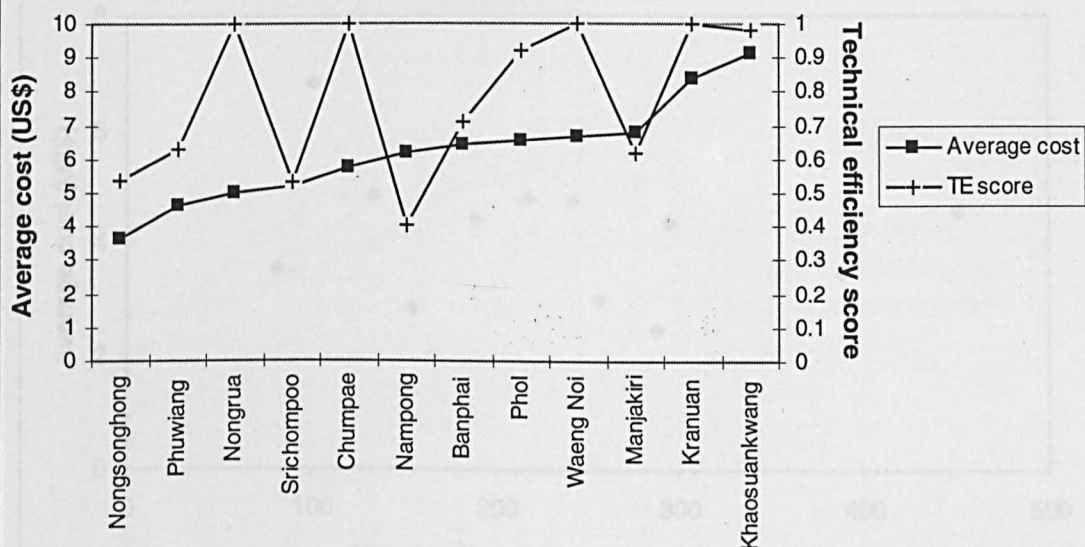
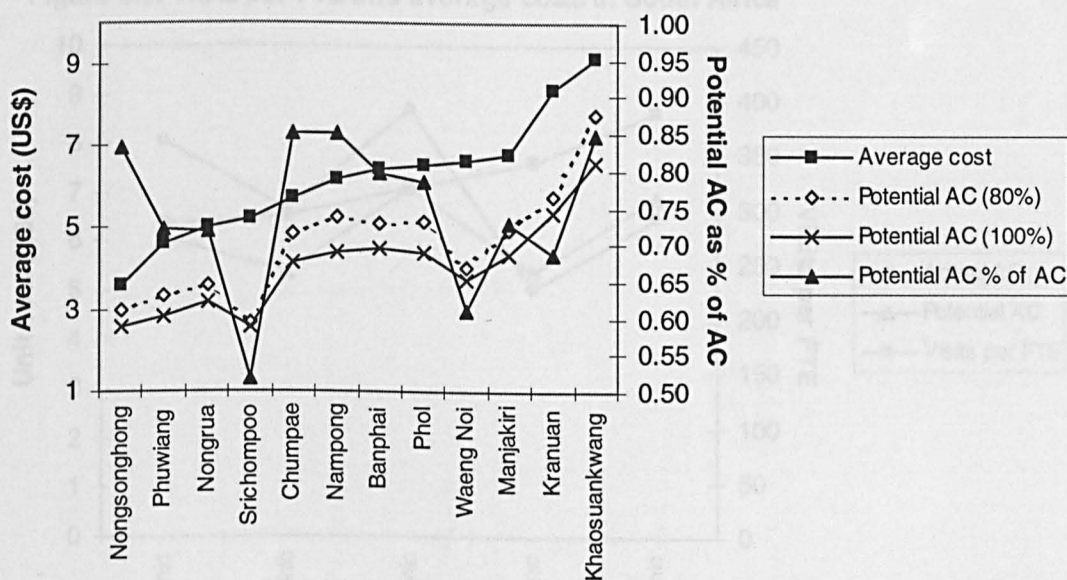


Figure 8.4: Average cost and returns to the variable factor for outpatient care in Thailand



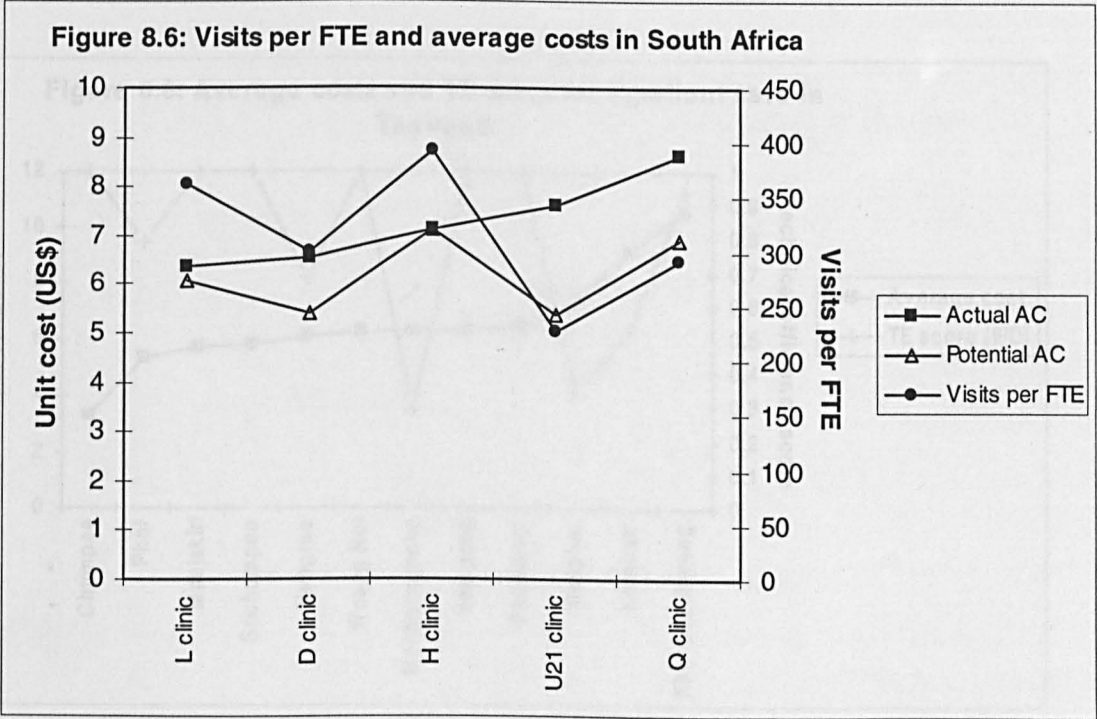
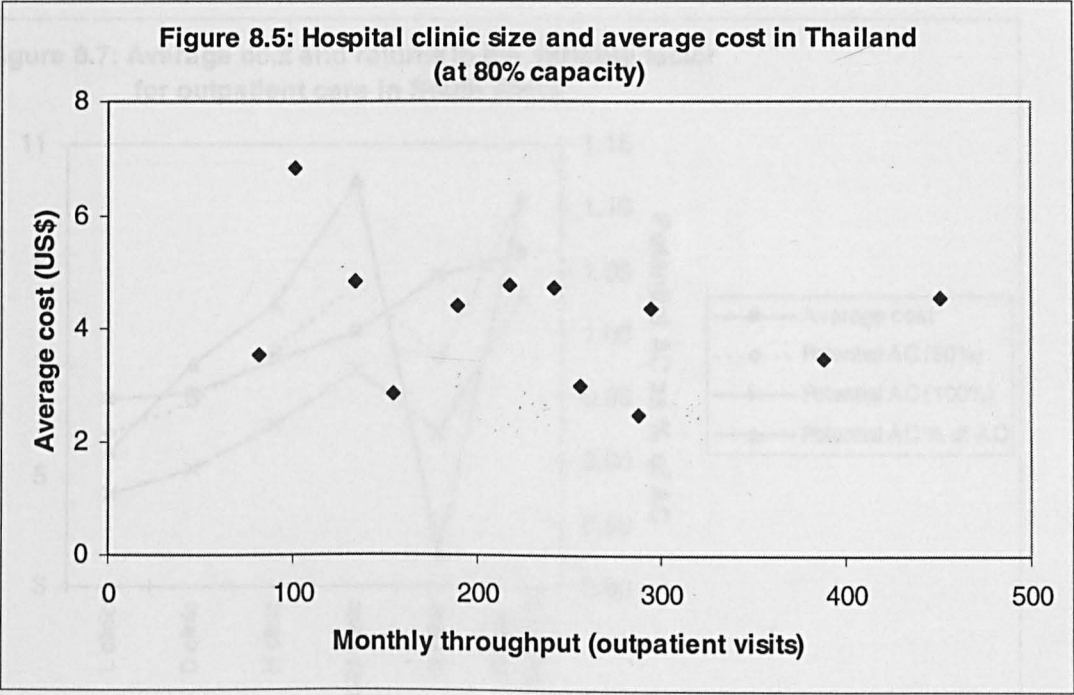


Figure 8.7: Average cost and returns to the variable factor for outpatient care in South Africa

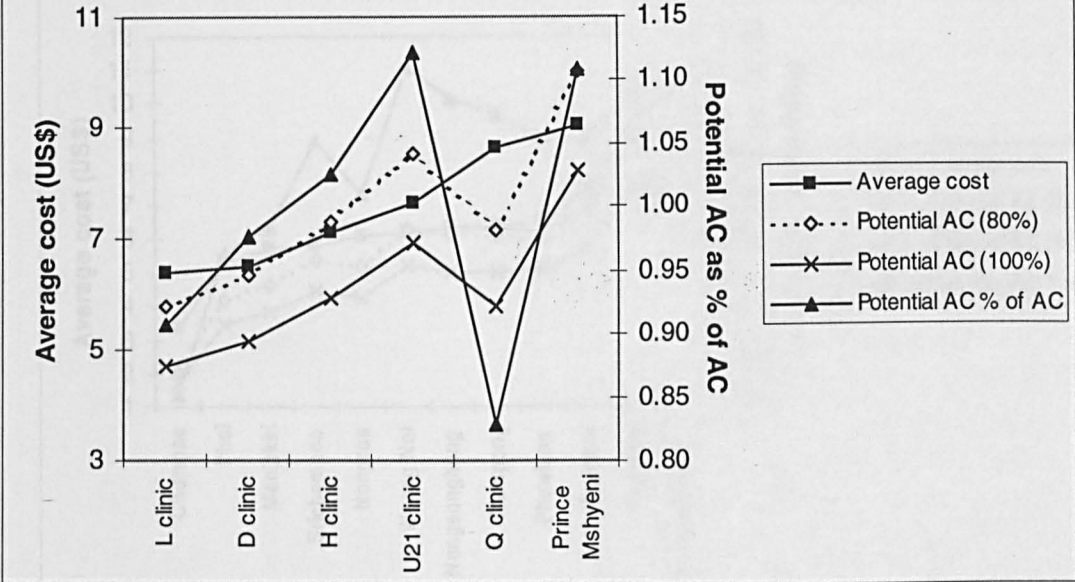
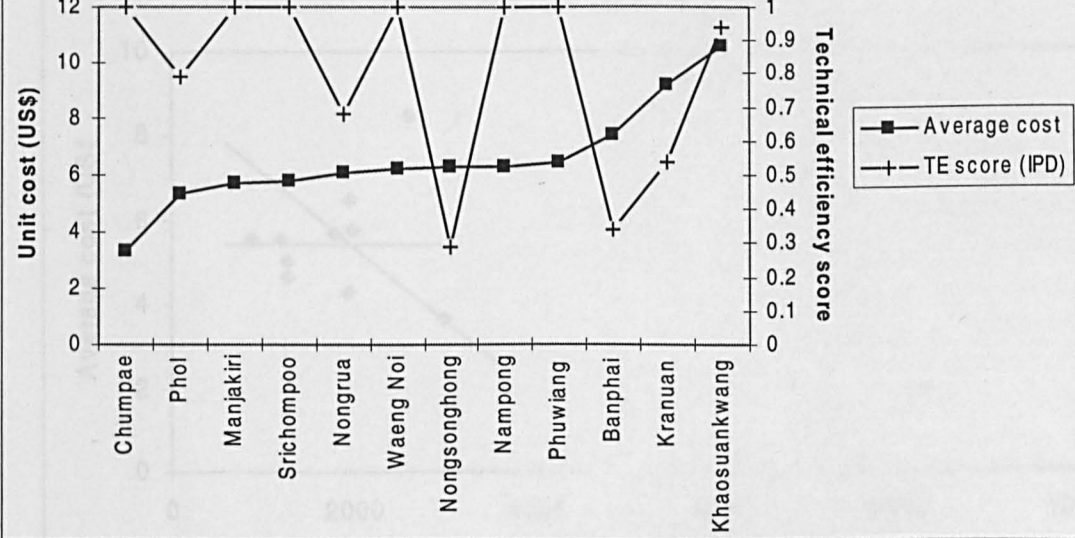


Figure 8.8: Average costs and TE score for inpatient care in Thailand



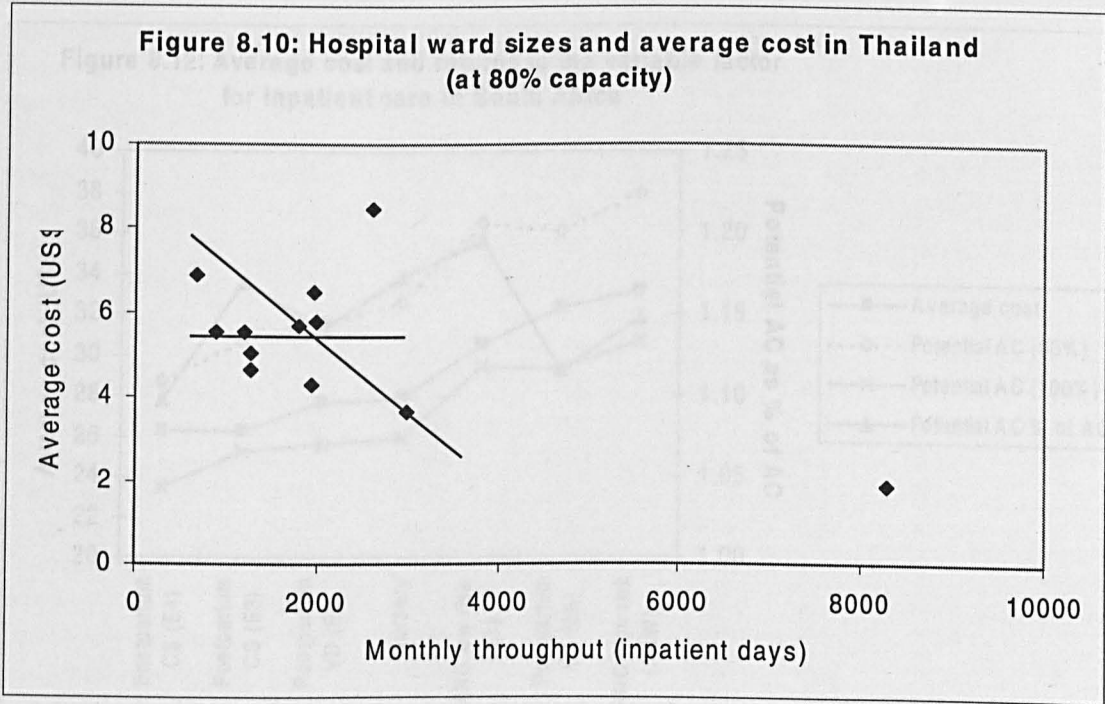
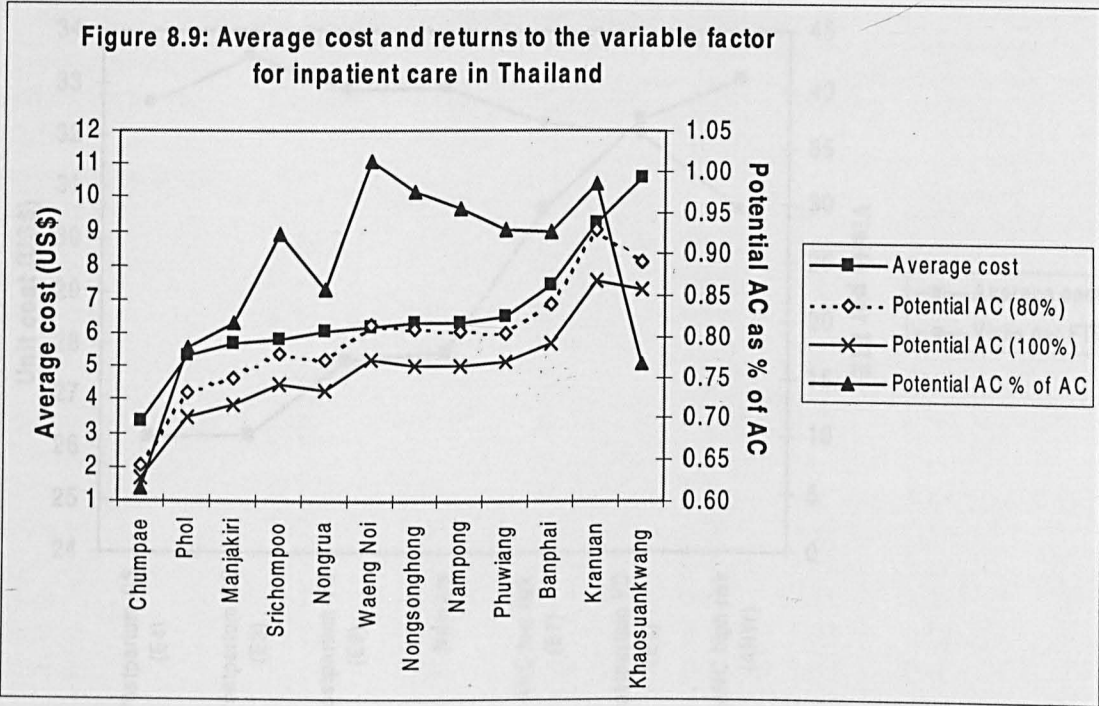


Figure 8.11: Days per FTE and average costs in South Africa

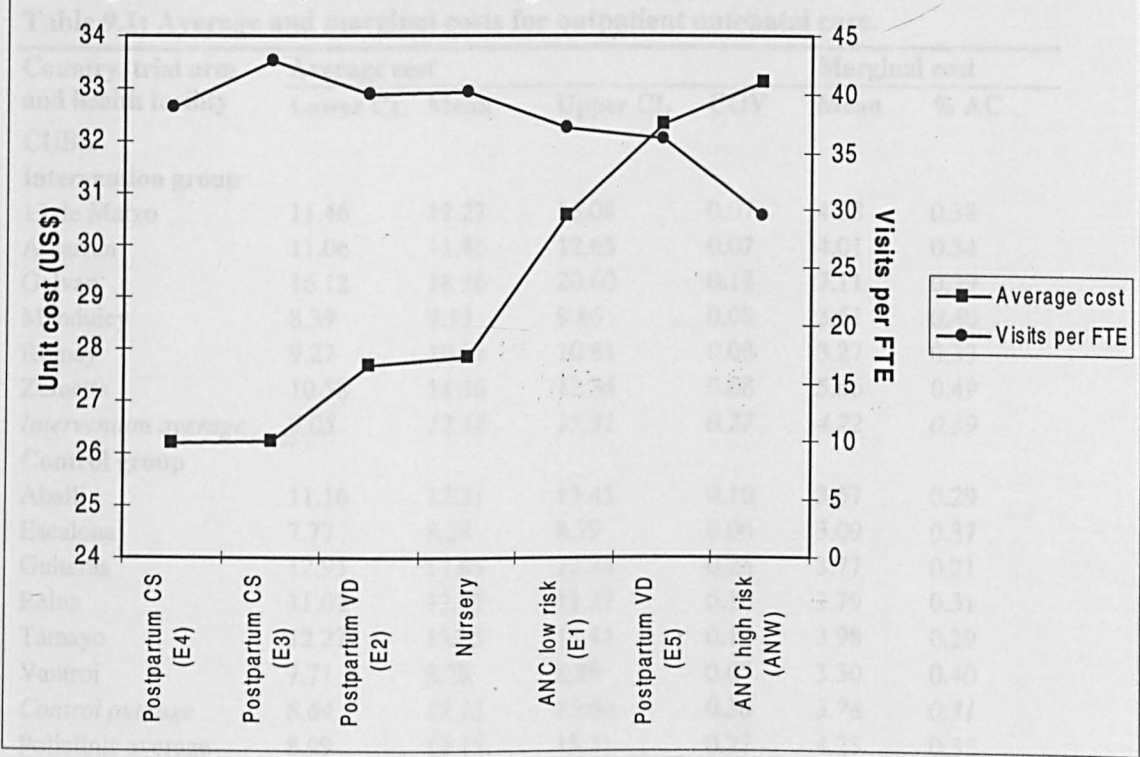
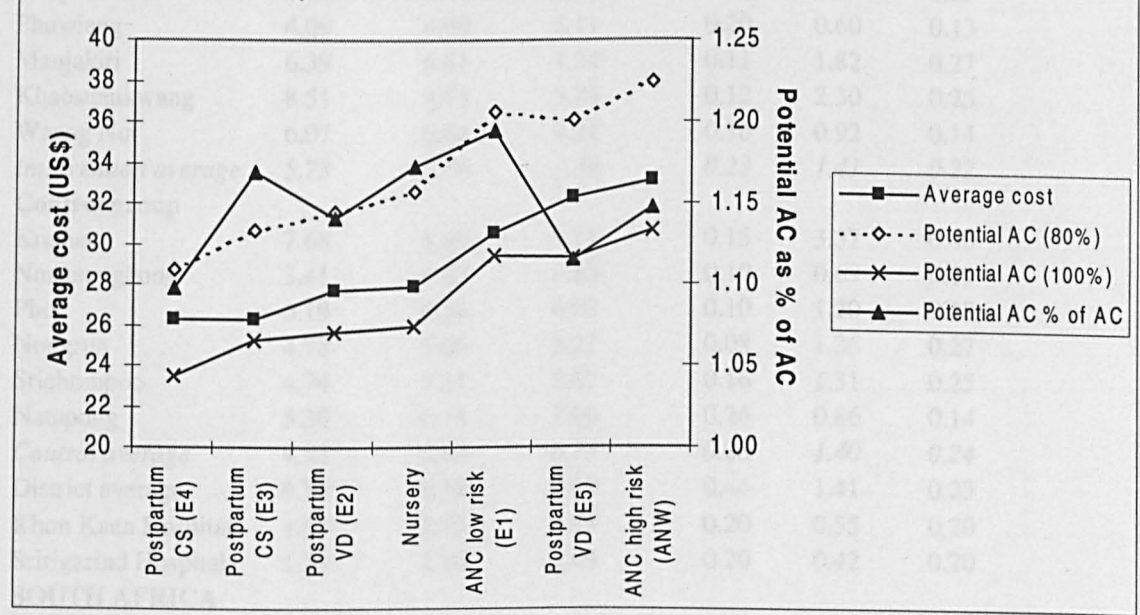


Figure 8.12: Average cost and returns to the variable factor for inpatient care in South Africa



Appendix 9: Unit cost results from Cuba, Thailand and South Africa**Table 9.1: Average and marginal costs for outpatient antenatal care.**

Country, trial arm and health facility	Average cost				Marginal cost	
	Lower CL	Mean	Upper CL	COV	Mean	% AC
CUBA						
Intervention group						
13 de Marzo	11.46	12.27	13.08	0.07	4.68	0.38
Albarran	11.06	11.86	12.65	0.07	4.01	0.34
Galvan	16.12	18.36	20.60	0.13	7.11	0.39
Manduley	8.39	9.13	9.86	0.08	3.61	0.40
Romay	9.22	10.01	10.81	0.08	3.27	0.33
Zuluetta	10.58	11.46	12.34	0.08	5.66	0.49
<i>Intervention average</i>	<i>9.05</i>	<i>12.18</i>	<i>15.31</i>	<i>0.27</i>	<i>4.72</i>	<i>0.39</i>
Control group						
Aballi	11.16	12.31	13.45	0.10	3.57	0.29
Escalona	7.77	8.28	8.79	0.06	3.09	0.37
Guiteras	12.95	17.85	22.74	0.28	3.77	0.21
Reina	11.02	12.15	13.27	0.10	3.79	0.31
Tamayo	12.27	13.85	15.44	0.12	3.98	0.29
Vantroi	7.71	8.28	8.86	0.07	3.30	0.40
<i>Control average</i>	<i>8.64</i>	<i>12.12</i>	<i>15.60</i>	<i>0.30</i>	<i>3.78</i>	<i>0.31</i>
Policlinic average	8.99	12.15	15.31	0.27	4.25	0.35
America Arias	2.82	3.22	3.62	0.13	0.64	0.20
THAILAND						
Intervention group						
Chumpae	5.36	5.73	6.10	0.12	1.23	0.22
Banphai	6.14	6.44	6.73	0.08	1.85	0.29
Phuwiang	4.09	4.60	5.11	0.20	0.60	0.13
Manjakiri	6.39	6.81	7.24	0.11	1.82	0.27
Khaosuankwang	8.51	9.13	9.75	0.12	2.30	0.25
Waeng Noi	6.07	6.64	7.21	0.16	0.92	0.14
<i>Intervention average</i>	<i>5.73</i>	<i>6.56</i>	<i>7.39</i>	<i>0.23</i>	<i>1.41</i>	<i>0.22</i>
Control group						
Kranuan	7.68	8.40	9.11	0.15	3.37	0.40
Nongsonghong	3.41	3.62	3.83	0.10	0.69	0.19
Phol	6.19	6.56	6.92	0.10	1.20	0.18
Nongrua	4.78	5.00	5.22	0.08	1.36	0.27
Srichompoo	4.74	5.21	5.67	0.16	1.31	0.25
Nampong	5.30	6.18	7.06	0.26	0.86	0.14
<i>Control average</i>	<i>4.92</i>	<i>5.83</i>	<i>6.73</i>	<i>0.28</i>	<i>1.40</i>	<i>0.24</i>
District average	4.70	6.19	7.69	0.44	1.41	0.23
Khon Kaen Hospital	1.67	2.75	3.83	0.20	0.55	0.20
Sririgarind Hospital	1.28	2.10	2.93	0.20	0.42	0.20
SOUTH AFRICA						
D clinic	4.30	6.51	8.72	0.21	0.36	0.06
H clinic	6.64	7.10	7.55	0.04	0.55	0.08
L clinic	4.21	6.38	8.54	0.21	0.37	0.06
Q clinic	5.59	8.63	11.66	0.22	0.37	0.04
U21 clinic	5.47	7.61	9.74	0.18	0.43	0.06
<i>Sample average</i>	<i>5.78</i>	<i>7.24</i>	<i>8.70</i>	<i>0.13</i>	<i>0.42</i>	<i>0.06</i>
Prince Mshyeni	7.47	9.05	10.62	0.11	0.95	0.11

Table 9.2: Average and marginal costs for inpatient antenatal/postpartum care.

Country, trial arm and health facility	Average cost				Marginal cost	
	Lower CL	Mean	Upper CL	COV	Mean	% AC
CUBA						
America Arias						
ANC high risk (AB)	39.37	51.72	64.07	0.25	10.39	0.20
ANC low risk (E)	23.95	30.84	37.72	0.23	6.80	0.22
Postpartum VD (C)	13.89	16.76	19.63	0.18	4.04	0.24
Postpartum CS (F)	29.14	36.75	44.35	0.21	8.78	0.24
Neonatology	88.37	118.09	147.82	0.26	31.32	0.27
THAILAND						
Intervention group						
Chumpae	2.95	3.34	3.73	0.21	0.20	0.06
Banphai	6.92	7.44	7.95	0.13	0.86	0.12
Phuwiang	6.10	6.48	6.87	0.11	1.47	0.23
Manjakiri	5.16	5.67	6.18	0.16	0.54	0.09
Khaosuankwang	9.69	10.60	11.51	0.16	2.80	0.26
Waeng Noi	5.66	6.20	6.73	0.16	0.91	0.15
<i>Intervention average</i>	<i>5.30</i>	<i>6.62</i>	<i>7.94</i>	<i>0.36</i>	<i>1.00</i>	<i>0.15</i>
Control group						
Kranuan	8.61	9.19	9.77	0.11	1.89	0.21
Nongsonghong	5.99	6.29	6.60	0.09	0.61	0.10
Phol	4.93	5.32	5.71	0.13	0.50	0.09
Nongrua	5.51	6.07	6.62	0.17	0.37	0.06
Srichompoo	5.35	5.81	6.27	0.14	1.53	0.26
Nampong	5.86	6.33	6.80	0.13	0.92	0.15
<i>Control average</i>	<i>5.74</i>	<i>6.50</i>	<i>7.26</i>	<i>0.21</i>	<i>0.94</i>	<i>0.14</i>
District average	5.54	6.56	7.58	0.28	0.97	0.15
Khon Kaen Hospital						
Postpartum CS	50.51	63.14	75.76	0.20	12.63	0.20
Obstetric cases	39.43	49.29	59.15	0.20	9.86	0.20
Neonatology	13.12	16.41	19.69	0.20	3.28	0.20
Sririgarind Hospital						
Postpartum CS	52.45	65.56	78.68	0.20	13.11	0.20
Obstetric cases	2.13	2.66	3.19	0.20	0.53	0.20
Neonatology	8.72	10.90	13.08	0.20	2.18	0.20
SOUTH AFRICA						
Prince Mshiyeni						
ANC high risk (ANW)	27.24	33.13	39.02	0.11	1.51	0.05
ANC low risk (E1)	29.34	30.56	31.78	0.03	1.26	0.04
Postpartum VD (E2)	22.57	27.67	32.77	0.12	3.34	0.12
Postpartum VD (E5)	27.30	32.34	37.37	0.10	2.18	0.07
Postpartum CS (E3)	24.63	26.25	27.86	0.04	3.64	0.14
Postpartum CS (E4)	21.84	26.21	30.58	0.10	2.24	0.09
Nursery	23.47	27.85	32.24	0.10	3.12	0.11

Table 9.3: Average and marginal costs for delivery care.

Country, trial arm and health facility	Average cost				Marginal cost	
	Lower CL	Mean	Upper CL	COV	Mean	% AC
CUBA						
America Arias						
Vaginal delivery	16.45	21.32	26.20	0.24	5.92	0.28
Caesarean section	70.12	113.98	157.83	0.40	43.73	0.38
THAILAND						
Vaginal delivery - Intervention group						
Chumpae	9.16	9.86	10.55	0.13	3.19	0.32
Banphai	37.47	40.05	42.63	0.12	2.82	0.07
Phuwiang	21.95	22.76	23.56	0.06	11.53	0.51
Manjakiri	29.96	31.53	33.10	0.09	4.27	0.14
Khaosuankwang	19.84	21.25	22.67	0.12	4.63	0.22
Waeng Noi	58.07	65.07	72.07	0.19	8.80	0.14
Intervention average	24.44	31.75	39.07	0.42	7.35	0.23
Vaginal delivery - Control group						
Kranuan	20.43	20.83	21.24	0.04	2.56	0.12
Nongsonghong	11.57	12.46	13.36	0.13	0.96	0.08
Phol	24.68	26.09	27.49	0.10	4.92	0.19
Nongrua	24.23	29.03	33.82	0.30	2.26	0.08
Srichompoo	23.35	25.05	26.75	0.12	8.88	0.35
Nampong	20.63	23.07	25.51	0.19	3.74	0.16
Control average	19.57	22.75	25.93	0.25	3.73	0.16
District average	19.17	27.25	35.34	0.54	5.39	0.20
Khon Kaen Hospital	35.14	39.10	43.06	0.20	7.82	0.20
Sririgarind Hospital	50.54	56.23	61.93	0.20	11.25	0.20
Caesarean section – Intervention group						
Chumpae		67.00			46.14	0.69
Banphai		47.27			27.53	0.58
Phuwiang		39.04			22.89	0.59
Manjakiri		83.00			59.00	0.71
Khaosuankwang		83.00			43.14	0.52
Waeng Noi		83.00			43.14	0.52
Intervention average		67.05			40.32	0.60
Caesarean section – Control group						
Kranuan		56.21			13.80	0.25
Nongsonghong		185.10			69.88	0.38
Phol		141.57			83.00	0.59
Nongrua		53.42			29.54	0.55
Srichompoo		83.00			53.29	0.64
Nampong		74.40			55.47	0.75
Control average		98.95			51.95	0.52
District average		83.00			46.74	0.56
Khon Kaen Hospital		63.14			12.63	0.20
Sririgarind Hospital		65.56			13.11	0.20
SOUTH AFRICA						
Prince Mshiyeni						
Labour and VD	74.49	81.40	88.30	0.05	5.38	0.07
Caesarean section	105.71	140.60	175.48	0.16	24.91	0.18

Table 9.4: Ingredients of outpatient antenatal care cost.

Country, trial arm and health facility	Money contribution to cost (US\$)						Percent contribution to cost (%)					
	Staff	Eq	Mat	Drug	Util	Build	Staff	Eq	Mat	Drug	Util	Build
CUBA												
Intervention group												
13 de Marzo	6.20	0.10	0.09	4.59	0.36	0.93	0.51	0.01	0.01	0.37	0.03	0.08
Albarran	7.48	0.07	0.06	3.95	0.04	0.25	0.63	0.01	0.01	0.33	0.00	0.02
Galvan	10.02	0.11	0.33	6.77	0.53	0.59	0.55	0.01	0.02	0.37	0.03	0.03
Manduley	4.97	0.11	0.11	3.50	0.09	0.34	0.54	0.01	0.01	0.38	0.01	0.04
Romay	6.09	0.08	0.13	3.14	0.31	0.27	0.61	0.01	0.01	0.31	0.03	0.03
Zulueta	5.13	0.04	0.08	5.58	0.20	0.42	0.45	0.00	0.01	0.49	0.02	0.04
<i>Intervention average</i>	<i>6.66</i>	<i>0.09</i>	<i>0.13</i>	<i>4.59</i>	<i>0.25</i>	<i>0.47</i>	<i>0.55</i>	<i>0.01</i>	<i>0.01</i>	<i>0.38</i>	<i>0.02</i>	<i>0.04</i>
Control group												
Aballi	8.09	0.12	0.10	3.48	0.21	0.31	0.66	0.01	0.01	0.28	0.02	0.02
Escalona	4.13	0.15	0.07	3.02	0.17	0.74	0.50	0.02	0.01	0.36	0.02	0.09
Guiteras	13.00	0.26	0.23	3.54	0.58	0.22	0.73	0.01	0.01	0.20	0.03	0.01
Reina	7.32	0.22	0.11	3.68	0.34	0.48	0.60	0.02	0.01	0.30	0.03	0.04
Tamayo	9.13	0.11	0.11	3.87	0.26	0.37	0.66	0.01	0.01	0.28	0.02	0.03
Vantroi	4.31	0.06	0.15	3.15	0.27	0.35	0.52	0.01	0.02	0.38	0.03	0.04
<i>Control average</i>	<i>7.41</i>	<i>0.15</i>	<i>0.13</i>	<i>3.65</i>	<i>0.30</i>	<i>0.48</i>	<i>0.61</i>	<i>0.01</i>	<i>0.01</i>	<i>0.30</i>	<i>0.02</i>	<i>0.04</i>
Policlinic average	7.04	0.12	0.13	4.12	0.27	0.47	0.58	0.01	0.01	0.34	0.02	0.04
America Arias	2.13	0.17	0.50	0.15	0.24	0.04	0.66	0.05	0.15	0.05	0.07	0.01
THAILAND												
Intervention group												
Chumpae	4.12	0.27	0.32	0.91	0.03	0.07	0.72	0.05	0.06	0.16	0.01	0.01
Banphai	4.16	0.27	0.58	1.27	0.00	0.16	0.65	0.04	0.09	0.20	0.00	0.03
Phuwiang	3.39	0.23	0.31	0.29	0.05	0.34	0.74	0.05	0.07	0.06	0.01	0.07
Manjakiri	4.23	0.40	0.45	1.37	0.11	0.25	0.62	0.06	0.07	0.20	0.02	0.04
Khaosuankwang	5.68	0.83	0.68	1.63	0.04	0.27	0.62	0.09	0.07	0.18	0.00	0.03
Waeng Noi	4.91	0.47	0.60	0.32	0.21	0.13	0.74	0.07	0.09	0.05	0.03	0.02
<i>Intervention average</i>	<i>4.47</i>	<i>0.39</i>	<i>0.49</i>	<i>0.92</i>	<i>0.07</i>	<i>0.22</i>	<i>0.68</i>	<i>0.06</i>	<i>0.07</i>	<i>0.14</i>	<i>0.01</i>	<i>0.03</i>
Control group												
Kranuan	4.28	0.46	2.59	0.78	0.29	0.10	0.51	0.06	0.31	0.09	0.03	0.01
Nongsonghong	2.40	0.23	0.15	0.55	0.03	0.27	0.66	0.06	0.04	0.15	0.01	0.07
Phol	5.00	0.20	0.27	0.93	0.06	0.10	0.76	0.03	0.04	0.14	0.01	0.02
Nongrua	2.72	0.58	0.50	0.86	0.04	0.29	0.54	0.12	0.10	0.17	0.01	0.06
Srichompoo	3.24	0.48	0.39	0.93	0.02	0.16	0.62	0.09	0.07	0.18	0.00	0.03
Nampong	4.57	0.43	0.56	0.30	0.20	0.12	0.74	0.07	0.09	0.05	0.03	0.02
<i>Control average</i>	<i>3.73</i>	<i>0.41</i>	<i>0.64</i>	<i>0.76</i>	<i>0.09</i>	<i>0.20</i>	<i>0.64</i>	<i>0.07</i>	<i>0.11</i>	<i>0.13</i>	<i>0.02</i>	<i>0.03</i>
District average	4.09	0.41	0.57	0.84	0.08	0.21	0.66	0.07	0.09	0.14	0.01	0.03
SOUTH AFRICA												
D clinic	5.68	0.06	0.19	0.17	0.15	0.26	0.87	0.01	0.03	0.03	0.02	0.04
H clinic	6.12	0.05	0.17	0.39	0.16	0.21	0.86	0.01	0.02	0.05	0.02	0.03
L clinic	5.60	0.05	0.21	0.16	0.17	0.18	0.88	0.01	0.03	0.03	0.03	0.03
Q clinic	7.89	0.04	0.16	0.21	0.13	0.19	0.91	0.01	0.02	0.02	0.02	0.02
U21 clinic	6.68	0.05	0.18	0.24	0.18	0.27	0.88	0.01	0.02	0.03	0.02	0.04
<i>Sample average</i>	<i>6.38</i>	<i>0.05</i>	<i>0.19</i>	<i>0.23</i>	<i>0.16</i>	<i>0.22</i>	<i>0.88</i>	<i>0.01</i>	<i>0.03</i>	<i>0.03</i>	<i>0.02</i>	<i>0.03</i>
Prince Mshyeni	6.23	0.03	0.19	0.76	0.75	1.08	0.69	0.00	0.02	0.08	0.08	0.12

Table 9.5: Ingredients of outpatient antenatal/postpartum inpatient cost.

Country, trial arm and health facility	Money contribution to cost (US\$)						Percent contribution to cost (%)					
	Staff	Eq	Mat	Drug	Util	Build	Staff	Eq	Mat	Drug	Util	Build
CUBA												
America Arias												
ANC high risk (AB)	34.93	2.77	8.54	1.85	3.36	0.27	0.68	0.05	0.17	0.04	0.06	0.01
ANC low risk (E)	21.35	1.06	4.87	1.93	1.48	0.16	0.69	0.03	0.16	0.06	0.05	0.01
Postpartum VD (C)	10.90	0.72	2.86	1.18	0.98	0.11	0.65	0.04	0.17	0.07	0.06	0.01
Postpartum CS (F)	24.34	1.31	5.93	2.85	2.08	0.24	0.66	0.04	0.16	0.08	0.06	0.01
Neonatology	75.90	5.87	23.10	8.21	4.57	0.44	0.64	0.05	0.20	0.07	0.04	0.00
THAILAND												
Intervention group												
Chumpae	2.66	0.18	0.18	0.02	0.12	0.18	0.80	0.05	0.06	0.01	0.04	0.05
Banphai	5.87	0.48	0.67	0.19	0.00	0.23	0.79	0.06	0.09	0.03	0.00	0.03
Phuwiang	4.34	0.31	1.22	0.25	0.06	0.31	0.67	0.05	0.19	0.04	0.01	0.05
Manjakiri	4.36	0.37	0.29	0.24	0.12	0.29	0.77	0.06	0.05	0.04	0.02	0.05
Khaosuankwang	6.16	0.63	1.95	0.86	0.05	0.95	0.58	0.06	0.18	0.08	0.00	0.09
Waeng Noi	4.35	0.47	0.74	0.17	0.20	0.27	0.70	0.08	0.12	0.03	0.03	0.04
<i>Intervention average</i>	<i>4.75</i>	<i>0.40</i>	<i>0.76</i>	<i>0.24</i>	<i>0.11</i>	<i>0.35</i>	<i>0.72</i>	<i>0.06</i>	<i>0.11</i>	<i>0.04</i>	<i>0.02</i>	<i>0.05</i>
Control group												
Kranuan	6.23	0.66	0.77	1.12	0.41	0.49	0.68	0.07	0.08	0.12	0.04	0.05
Nongsonghong	4.35	0.75	0.10	0.52	0.13	0.45	0.69	0.12	0.02	0.08	0.02	0.07
Phol	4.37	0.21	0.43	0.07	0.04	0.20	0.82	0.04	0.08	0.01	0.01	0.04
Nongrua	4.78	0.44	0.33	0.04	0.08	0.39	0.79	0.07	0.05	0.01	0.01	0.06
Srichompoo	3.55	0.36	0.83	0.69	0.03	0.34	0.61	0.06	0.14	0.12	0.01	0.06
Nampong	4.44	0.48	0.75	0.17	0.21	0.28	0.70	0.08	0.12	0.03	0.03	0.04
<i>Control average</i>	<i>4.65</i>	<i>0.48</i>	<i>0.54</i>	<i>0.40</i>	<i>0.13</i>	<i>0.36</i>	<i>0.72</i>	<i>0.07</i>	<i>0.08</i>	<i>0.06</i>	<i>0.02</i>	<i>0.05</i>
District average	4.70	0.44	0.65	0.32	0.12	0.35	0.72	0.07	0.10	0.05	0.02	0.05
SOUTH AFRICA												
Prince Mshiyeni												
ANC high risk (ANW)	28.35	0.10	0.85	0.66	1.57	1.59	0.86	0.00	0.03	0.02	0.05	0.05
ANC low risk (E1)	24.84	0.10	0.80	0.45	2.46	1.90	0.81	0.00	0.03	0.01	0.08	0.06
Postpartum VD (E2)	21.12	0.38	2.28	1.06	1.27	1.56	0.76	0.01	0.08	0.04	0.05	0.06
Postpartum VD (E5)	26.39	0.14	1.71	0.47	1.56	2.06	0.82	0.00	0.05	0.01	0.05	0.06
Postpartum CS (E3)	19.81	0.07	2.45	1.19	1.16	1.55	0.75	0.00	0.09	0.05	0.04	0.06
Postpartum CS (E4)	20.97	0.10	1.24	1.00	1.23	1.67	0.80	0.00	0.05	0.04	0.05	0.06
Nursery	19.34	2.12	2.35	0.76	1.39	1.89	0.69	0.08	0.08	0.03	0.05	0.07

Table 9.6: Ingredients of delivery care cost.

Country, trial arm and health facility	Money contribution to cost (US\$)						Percent contribution to cost (%)					
	Staff	Eq	Mat	Drug	Util	Build	Staff	Eq	Mat	Drug	Util	Build
CUBA												
America Arias												
Vaginal delivery	12.92	1.04	4.40	1.52	1.34	0.11	0.61	0.05	0.21	0.07	0.06	0.01
Caesarean section	65.03	2.03	21.51	22.22	2.76	0.44	0.57	0.02	0.19	0.19	0.02	0.00
THAILAND												
Vaginal delivery - Intervention group												
Chumpae	6.34	0.13	2.54	0.65	0.07	0.13	0.64	0.01	0.26	0.07	0.01	0.01
Banphai	33.45	2.89	2.81	0.01	0.00	0.89	0.84	0.07	0.07	0.00	0.00	0.02
Phuwiang	9.10	1.38	11.30	0.23	0.19	0.55	0.40	0.06	0.50	0.01	0.01	0.02
Manjakiri	23.29	2.36	2.72	1.54	0.61	1.00	0.74	0.07	0.09	0.05	0.02	0.03
Khaosuankwang	10.50	4.98	1.89	2.74	0.10	1.05	0.49	0.23	0.09	0.13	0.00	0.05
Waeng Noi	36.81	13.18	6.98	1.82	1.05	5.24	0.57	0.20	0.11	0.03	0.02	0.08
<i>Intervention average</i>	19.46	3.48	5.86	1.49	0.30	1.17	0.61	0.11	0.18	0.05	0.01	0.04
Vaginal delivery - Control group												
Kranuan	15.82	1.52	0.00	2.56	0.94	0.27	0.76	0.07	0.00	0.12	0.04	0.01
Nongsonghong	7.17	2.21	0.09	0.87	0.91	1.22	0.58	0.18	0.01	0.07	0.07	0.10
Phol	19.53	0.86	3.05	1.87	0.27	0.50	0.75	0.03	0.12	0.07	0.01	0.02
Nongrua	22.36	2.04	1.76	0.50	0.29	2.08	0.77	0.07	0.06	0.02	0.01	0.07
Srichompoo	14.08	1.02	4.33	4.55	0.13	0.93	0.56	0.04	0.17	0.18	0.01	0.04
Nampong	16.40	1.60	2.99	0.75	0.85	0.48	0.71	0.07	0.13	0.03	0.04	0.02
<i>Control average</i>	15.65	1.76	1.85	1.88	0.68	0.98	0.69	0.08	0.08	0.08	0.03	0.04
District average	17.72	2.55	3.62	1.77	0.54	1.09	0.65	0.09	0.13	0.06	0.02	0.04
Caesarean section - Intervention group												
Chumpae	12.56	5.11	16.70	29.44	0.91	2.28	0.19	0.08	0.25	0.44	0.01	0.03
Banphai	10.90	7.74	19.91	7.62	0.01	1.10	0.23	0.16	0.42	0.16	0.00	0.02
Phuwiang	4.45	4.43	14.08	8.81	1.34	5.93	0.11	0.11	0.36	0.23	0.03	0.15
Manjakiri	18.63	3.76	30.29	28.71	0.50	1.12	0.22	0.05	0.36	0.35	0.01	0.01
Khaosuankwang	34.09	3.69	18.50	24.65	0.38	1.70	0.41	0.04	0.22	0.30	0.00	0.02
Waeng Noi	34.09	3.69	18.50	24.65	0.38	1.70	0.41	0.04	0.22	0.30	0.00	0.02
<i>Intervention average</i>	17.63	5.45	20.58	19.74	0.70	2.95	0.26	0.08	0.31	0.29	0.01	0.04
Caesarean section - Control group												
Kranuan	34.08	8.26	13.40	0.40	0.02	0.06	0.61	0.15	0.24	0.01	0.00	0.00
Nongsonghong	109.72	3.70	41.78	28.09	0.37	1.44	0.59	0.02	0.23	0.15	0.00	0.01
Phol	16.15	16.06	51.07	31.93	4.86	21.50	0.11	0.11	0.36	0.23	0.03	0.15
Nongrua	10.38	9.04	11.66	17.88	0.72	3.75	0.19	0.17	0.22	0.33	0.01	0.07
Srichompoo	15.70	8.27	28.97	24.32	1.12	4.62	0.19	0.10	0.35	0.29	0.01	0.06
Nampong	18.12	0.60	21.83	33.64	0.14	0.08	0.24	0.01	0.29	0.45	0.00	0.00
<i>Control average</i>	31.99	9.19	27.80	24.15	1.08	4.74	0.32	0.09	0.28	0.24	0.01	0.05
District average	24.33	7.23	24.40	22.34	0.89	3.81	0.29	0.09	0.29	0.27	0.01	0.05
SOUTH AFRICA												
Prince Mshiyeni												
Labour and VD	66.82	0.17	3.88	1.50	3.77	5.25	0.82	0.00	0.05	0.02	0.05	0.06
Caesarean section	103.91	2.35	17.74	7.17	4.79	4.65	0.74	0.02	0.13	0.05	0.03	0.03

Key: Direct – direct health care costs; Admin – administrative costs; Lab – laboratory costs; Tech – departments providing direct support to health care departments; Gen – general services.

Table 9.7: Components of antenatal outpatient cost.

Country, trial arm and health facility	Components of cost (US\$)					Components of cost (%)				
	Direct	Admin	Lab	Tech	Gen	Direct	Admin	Lab	Tech	Gen
CUBA										
Intervention group										
13 de Marzo	10.27	0.62	0.58	0.25	0.55	0.84	0.05	0.05	0.02	0.04
Albarran	9.92	1.35	0.26	0.15	0.18	0.84	0.11	0.02	0.01	0.01
Galvan	13.55	1.93	1.62	0.10	1.16	0.74	0.11	0.09	0.01	0.06
Manduley	7.46	1.13	0.23	0.10	0.21	0.82	0.12	0.02	0.01	0.02
Romay	8.29	0.93	0.33	0.06	0.40	0.83	0.09	0.03	0.01	0.04
Zulueta	8.76	1.08	1.04	0.08	0.49	0.77	0.09	0.09	0.01	0.04
<i>Intervention average</i>	<i>9.79</i>	<i>1.18</i>	<i>0.62</i>	<i>0.13</i>	<i>0.46</i>	<i>0.80</i>	<i>0.10</i>	<i>0.05</i>	<i>0.01</i>	<i>0.04</i>
Control group										
Aballi	10.79	0.59	0.47	0.11	0.35	0.88	0.05	0.04	0.01	0.03
Escalona	7.40	0.38	0.19	0.12	0.20	0.89	0.05	0.02	0.01	0.02
Guiteras	14.94	0.86	0.57	0.48	1.00	0.84	0.05	0.03	0.03	0.06
Reina	10.68	0.64	0.43	0.14	0.26	0.88	0.05	0.04	0.01	0.02
Tamayo	10.65	1.57	1.01	0.12	0.51	0.77	0.11	0.07	0.01	0.04
Vantroi	6.52	1.04	0.15	0.08	0.50	0.79	0.13	0.02	0.01	0.06
<i>Control average</i>	<i>10.18</i>	<i>0.88</i>	<i>0.44</i>	<i>0.16</i>	<i>0.46</i>	<i>0.84</i>	<i>0.07</i>	<i>0.04</i>	<i>0.01</i>	<i>0.04</i>
Policlinic average	9.99	1.03	0.53	0.14	0.46	0.82	0.08	0.04	0.01	0.04
America Arias	0.91	0.12	1.50	0.62	0.07	0.28	0.04	0.47	0.19	0.02
THAILAND										
Intervention group										
Chumpae	2.92	0.32	1.76	0.53	0.19	0.51	0.06	0.31	0.09	0.03
Banphai	4.38	0.37	0.32	1.02	0.34	0.68	0.06	0.05	0.16	0.05
Phuwiang	3.09	0.33	0.46	0.52	0.20	0.67	0.07	0.10	0.11	0.04
Manjakiri	4.40	0.46	0.57	0.72	0.67	0.65	0.07	0.08	0.11	0.10
Khaosuankwang	5.20	0.75	0.52	2.45	0.21	0.57	0.08	0.06	0.27	0.02
Waeng Noi	3.95	0.55	0.64	0.93	0.57	0.59	0.08	0.10	0.14	0.09
<i>Intervention average</i>	<i>4.01</i>	<i>0.45</i>	<i>0.76</i>	<i>0.96</i>	<i>0.37</i>	<i>0.61</i>	<i>0.07</i>	<i>0.12</i>	<i>0.15</i>	<i>0.06</i>
Control group										
Kranuan	4.84	0.33	1.07	1.80	0.35	0.58	0.04	0.13	0.21	0.04
Nongsonghong	2.23	0.19	0.51	0.54	0.15	0.62	0.05	0.14	0.15	0.04
Phol	4.40	0.32	0.90	0.61	0.34	0.67	0.05	0.14	0.09	0.05
Nongrua	3.67	0.17	0.27	0.57	0.31	0.73	0.03	0.05	0.11	0.06
Srichompoo	3.24	0.42	0.36	0.77	0.40	0.62	0.08	0.07	0.15	0.08
Nampong	3.75	0.41	0.37	1.07	0.57	0.61	0.07	0.06	0.17	0.09
<i>Control average</i>	<i>3.72</i>	<i>0.31</i>	<i>0.57</i>	<i>0.87</i>	<i>0.36</i>	<i>0.64</i>	<i>0.05</i>	<i>0.10</i>	<i>0.15</i>	<i>0.06</i>
District average	3.87	0.38	0.66	0.91	0.36	0.62	0.06	0.11	0.15	0.06
SOUTH AFRICA										
D clinic	4.77	0.45	0.82	0.00	0.47	0.73	0.07	0.13	0.00	0.07
H clinic	4.96	0.39	0.91	0.00	0.83	0.70	0.06	0.13	0.00	0.12
L clinic	4.34	0.44	0.81	0.00	0.79	0.68	0.07	0.13	0.00	0.12
Q clinic	6.73	0.48	0.71	0.00	0.71	0.78	0.06	0.08	0.00	0.08
U21 clinic	5.33	0.41	0.84	0.00	1.02	0.70	0.05	0.11	0.00	0.13
<i>Control average</i>	<i>5.20</i>	<i>0.44</i>	<i>0.83</i>	<i>0.00</i>	<i>0.77</i>	<i>0.72</i>	<i>0.06</i>	<i>0.11</i>	<i>0.00</i>	<i>0.11</i>
Prince Mshyeni	7.89	0.21	0.36	0.35	0.24	0.87	0.02	0.04	0.04	0.03

Key: Direct – direct health care costs; Admin – administrative costs; Lab – laboratory costs; Tech – departments providing direct support to health care departments; Gen – general services.

Table 9.8: Components of antenatal/postpartum inpatient cost.

Country, trial arm and health facility	Components of cost (US\$)					Components of cost (%)				
	Direct	Admin	Lab	Tech	Gen	Direct	Admin	Lab	Tech	Gen
CUBA										
America Arias										
ANC high risk (AB)	21.07	2.64	12.47	13.97	1.58	0.41	0.05	0.24	0.27	0.03
ANC low risk (E)	13.25	1.53	7.02	8.11	0.92	0.43	0.05	0.23	0.26	0.03
Postpartum VD (C)	6.88	0.92	3.54	4.87	0.55	0.41	0.05	0.21	0.29	0.03
Postpartum CS (F)	15.84	1.89	7.86	10.02	1.13	0.43	0.05	0.21	0.27	0.03
Neonatology	60.45	6.36	13.90	33.58	3.80	0.51	0.05	0.12	0.28	0.03
THAILAND										
Intervention group										
Chumpae	2.26	0.24	0.28	0.41	0.15	0.68	0.07	0.08	0.12	0.04
Banphai	4.97	0.52	0.77	0.84	0.33	0.67	0.07	0.10	0.11	0.04
Phuwiang	4.61	0.55	0.11	0.88	0.34	0.71	0.08	0.02	0.14	0.05
Manjakiri	3.96	0.39	0.16	0.61	0.56	0.70	0.07	0.03	0.11	0.10
Khaosuanwang	7.59	0.61	0.21	2.01	0.17	0.72	0.06	0.02	0.19	0.02
Waeng Noi	4.05	0.41	0.61	0.70	0.43	0.65	0.07	0.10	0.11	0.07
<i>Intervention average</i>	<i>4.55</i>	<i>0.46</i>	<i>0.39</i>	<i>0.86</i>	<i>0.36</i>	<i>0.69</i>	<i>0.07</i>	<i>0.06</i>	<i>0.13</i>	<i>0.05</i>
Control group										
Kranuan	6.22	0.33	0.50	1.80	0.35	0.68	0.04	0.05	0.20	0.04
Nongsonghong	4.23	0.38	0.28	1.07	0.30	0.67	0.06	0.05	0.17	0.05
Phol	3.25	0.43	0.33	0.84	0.46	0.61	0.08	0.06	0.16	0.09
Nongrua	4.26	0.27	0.17	0.89	0.48	0.70	0.04	0.03	0.15	0.08
Srichompoo	4.39	0.34	0.14	0.62	0.46	0.76	0.06	0.02	0.11	0.08
Nampong	3.98	0.39	0.38	1.02	0.55	0.63	0.06	0.06	0.16	0.09
<i>Control average</i>	<i>4.38</i>	<i>0.37</i>	<i>0.30</i>	<i>1.02</i>	<i>0.46</i>	<i>0.67</i>	<i>0.06</i>	<i>0.05</i>	<i>0.16</i>	<i>0.07</i>
District average	4.47	0.42	0.34	0.94	0.41	0.68	0.06	0.05	0.14	0.06
SOUTH AFRICA										
Prince Mshiyeni										
ANC high risk (ANW)	27.46	1.31	0.57	2.23	1.56	0.83	0.04	0.02	0.07	0.05
ANC low risk (E1)	25.92	1.21	0.16	1.92	1.35	0.85	0.04	0.01	0.06	0.04
Postpartum VD (E2)	23.20	1.13	0.27	1.80	1.27	0.84	0.04	0.01	0.07	0.05
Postpartum VD (E5)	26.14	1.25	1.56	1.99	1.40	0.81	0.04	0.05	0.06	0.04
Postpartum CS (E3)	22.16	1.02	0.31	1.61	1.14	0.84	0.04	0.01	0.06	0.04
Postpartum CS (E4)	21.82	1.10	0.31	1.75	1.24	0.83	0.04	0.01	0.07	0.05
Nursery	23.92	1.01	0.15	1.62	1.15	0.86	0.04	0.01	0.06	0.04

Key: Direct – direct health care costs; Admin – administrative costs; Lab – laboratory costs; Tech – departments providing direct support to health care departments; Gen – general services.

Table 9.9: Components of delivery care cost.

Country, trial arm and health facility	Components of cost (US\$)					Components of cost (%)				
	Direct	Admin	Lab	Tech	Gen	Direct	Admin	Lab	Tech	Gen
CUBA										
America Arias										
Vaginal delivery	8.36	1.03	5.81	5.51	0.62	0.39	0.05	0.27	0.26	0.03
Caesarean section	69.93	6.40	0.00	33.82	3.82	0.61	0.06	0.00	0.30	0.03
THAILAND										
Vaginal delivery - Intervention group										
Chumpae	7.49	0.72	0.00	1.21	0.44	0.76	0.07	0.00	0.12	0.04
Banphai	32.55	1.61	0.00	4.42	1.47	0.81	0.04	0.00	0.11	0.04
Phuwiang	14.81	2.46	0.00	3.96	1.53	0.65	0.11	0.00	0.17	0.07
Manjakiri	25.40	1.53	0.00	2.39	2.21	0.81	0.05	0.00	0.08	0.07
Khaosuankwang	16.40	1.06	0.00	3.50	0.30	0.77	0.05	0.00	0.16	0.01
Waeng Noi	41.72	6.24	0.00	10.60	6.51	0.64	0.10	0.00	0.16	0.10
<i>Intervention average</i>	23.50	2.20	0.00	4.29	1.76	0.74	0.07	0.00	0.14	0.06
Vaginal delivery - Control group										
Kranuan	17.99	0.38	0.00	2.06	0.41	0.86	0.02	0.00	0.10	0.02
Nongsonghong	9.06	0.74	0.00	2.07	0.59	0.73	0.06	0.00	0.17	0.05
Phol	18.06	2.00	0.00	3.87	2.15	0.69	0.08	0.00	0.15	0.08
Nongrua	21.88	1.16	0.00	3.89	2.10	0.75	0.04	0.00	0.13	0.07
Srichompoo	19.46	1.48	0.00	2.70	1.41	0.78	0.06	0.00	0.11	0.06
Nampong	17.34	1.15	0.00	2.98	1.60	0.75	0.05	0.00	0.13	0.07
<i>Control average</i>	17.31	1.15	0.00	2.98	1.32	0.76	0.05	0.00	0.13	0.06
District average	20.45	1.63	0.00	3.62	1.54	0.75	0.06	0.00	0.13	0.06
SOUTH AFRICA										
Prince Mshiyeni										
Labour and VD	71.50	2.78	0.18	3.81	3.13	0.88	0.03	0.00	0.05	0.04
Caesarean section	130.85	2.51	0.34	4.06	2.85	0.93	0.02	0.00	0.03	0.02

Key: Direct – direct health care costs; Admin – administrative costs; Lab – laboratory costs; Tech – departments providing direct support to health care departments; Gen – general services.

Table 9.10: Sensitivity analysis results for changes in prices and length of life of capital items.

Health care	Country	Average cost			Equipment		Traded goods		Capital items				Wages	
		Low	Base	High	Cost ↑ 50%		Cost ↑ 50%		LoL ↑ 100%		LoL ↓ 50%		Cost ↑ 50%	
					AC	%Δ	AC	%Δ	AC	%Δ	AC	%Δ	AC	%Δ
ANC	Cuba	11.1	11.9	12.6	11.9	0.00	13.9	0.17	11.7	-0.01	12.2	0.03	15.6	0.31
	Thai	6.1	6.6	7.2	6.9	0.03	7.3	0.10	6.3	-0.05	7.2	0.09	9.1	0.37
	S.Africa	4.2	6.4	8.5	6.4	0.00	6.6	0.03	6.3	-0.02	6.6	0.04	9.2	0.44
IPC	Cuba	23.9	30.8	37.7	31.4	0.02	34.8	0.13	30.2	-0.02	32.1	0.04	41.5	0.35
	Thai	5.7	6.2	6.7	6.4	0.04	6.9	0.11	5.8	-0.06	6.9	0.12	8.4	0.35
	S.Africa	29.3	30.6	31.8	30.6	0.00	31.2	0.02	29.6	-0.03	32.6	0.07	43.0	0.41
VD	Cuba	16.4	21.3	26.2	21.9	0.02	24.8	0.16	20.8	-0.03	22.5	0.05	27.8	0.30
	Thai	20.6	23.1	25.5	25.4	0.10	27.0	0.17	19.8	-0.14	29.6	0.28	29.6	0.28
	S.Africa	74.5	81.4	88.3	81.5	0.00	84.2	0.03	78.7	-0.03	86.8	0.07	114.8	0.41
CS	Cuba	70.1	114.0	157.9	115.0	0.01	136.9	0.20	112.7	-0.01	116.4	0.02	146.5	0.29
	Thai	52.08	74.4	96.7	78.1	0.05	102.0	0.37	68.6	-0.08	86.0	0.16	81.4	0.09
	S.Africa	105.7	140.6	175.5	141.8	0.01	154.2	0.10	137.1	-0.02	147.6	0.05	192.6	0.37
PP	Cuba	13.9	16.8	19.6	17.1	0.02	19.1	0.14	16.3	-0.03	17.6	0.05	22.2	0.33
	S.Africa	22.6	27.7	32.8	27.9	0.01	29.5	0.07	26.7	-0.04	29.6	0.07	38.2	0.38
NN	Cuba	96.7	118.1	139.5	121.0	0.02	136.7	0.16	114.9	-0.03	124.4	0.05	156.0	0.32
	S.Africa	23.5	27.9	32.2	28.9	0.04	30.5	0.09	25.9	-0.07	31.9	0.14	37.5	0.35

%Δ - percentage change; **Figures in bold** means that the AC range is larger than the lower or higher confidence limits

Table 9.11: Sensitivity analysis results for use of pooled drug cost.

Cuban polyclinics	Average cost under:		% change	Thai hospitals	Average cost under:		% change
	Base	Pooled		Base	Base	Pooled	
13 de Marzo	12.27	12.36	0.01	Chumpae	5.73	5.74	0.00
Albarran	11.86	12.52	0.06	Banphai	6.44	6.10	-0.05
Galvan	18.36	15.94	-0.13	Phuwiang	4.60	5.24	0.14
Manduley	9.12	10.13	0.11	Manjakiri	6.82	6.38	-0.06
Romay	10.01	11.60	0.16	Khaosuanwang	9.13	8.43	-0.08
Zuluetta	11.46	10.52	-0.08	Waeng Noi	6.64	7.24	0.09
Aballi	12.31	11.98	-0.03	Kranuan	8.40	8.34	-0.01
Escalona	8.28	8.80	0.06	Nongsonghong	3.62	3.79	0.05
Guiteras	17.85	18.13	0.02	Phol	6.56	6.35	-0.03
Reina	12.15	11.90	-0.02	Nongrua	5.00	4.86	-0.03
Tamayo	13.86	13.82	0.00	Srichompoo	5.21	5.00	-0.04
Vantroi	8.28	8.08	-0.02	Nampong	6.18	6.61	0.07

Figures in bold means that the AC range is larger than the lower or higher confidence limits

Table 9.12: Sensitivity analysis results for changes in methodology.

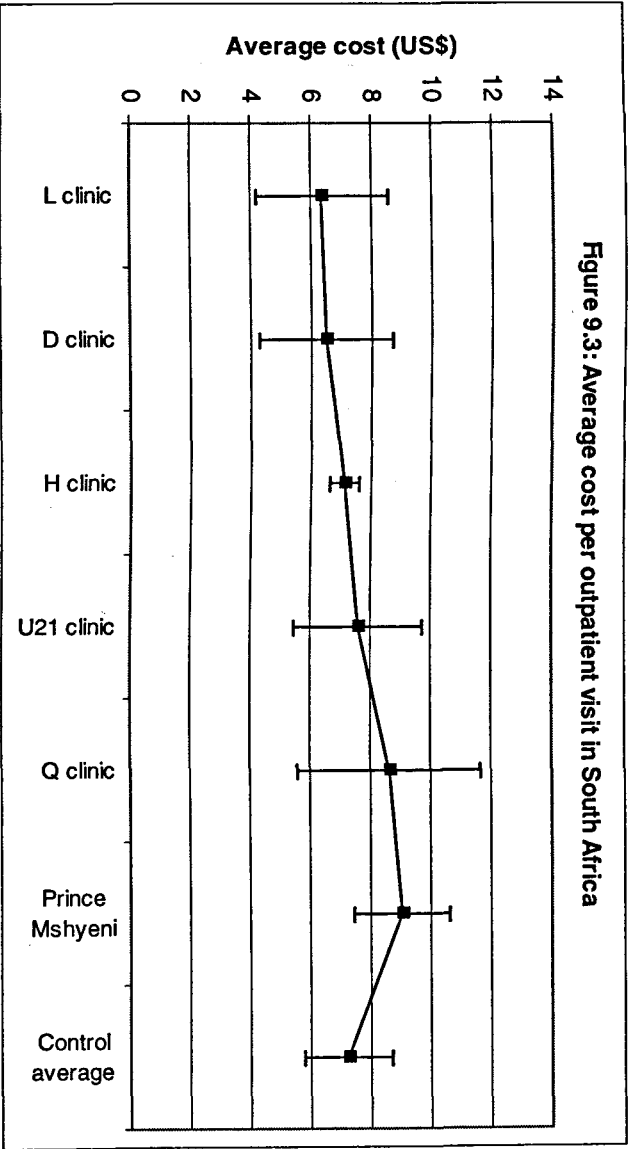
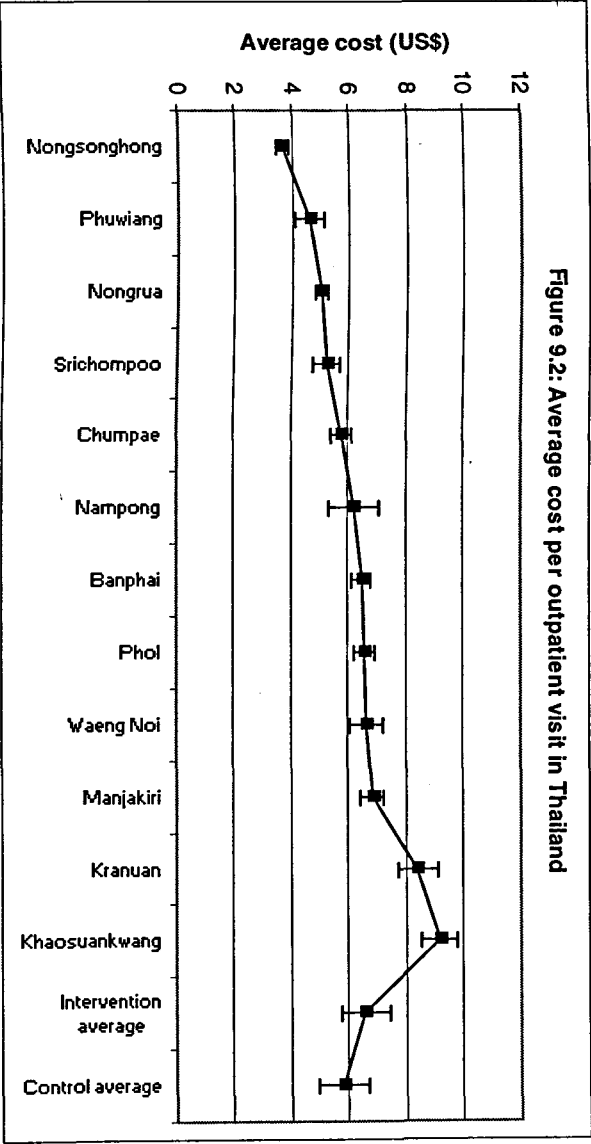
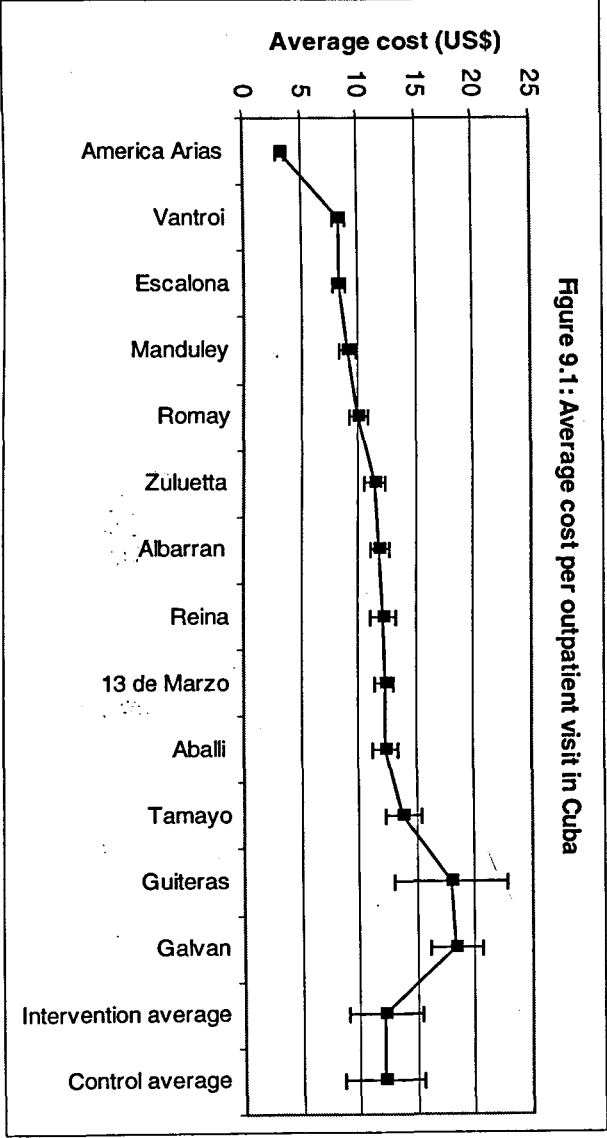
Health care	Country	Average cost (US\$)			Simultan. step-down allocation				Exchange alternative	
		Low	Base	High	% cost direct	20% less		20% more		% diff (US\$)
						AC (US\$)	% diff	AC (US\$)	% diff	
ANC	Cuba	11.1	11.9	12.6	0.86	11.5	-0.03	12.2	0.03	4.4 -0.63
Outpatient	Thai	6.1	6.6	7.2	0.69	6.2	-0.06	7.1	0.06	9.4 0.42
Visit	S.Africa	4.2	6.4	8.5	0.81	6.1	-0.04	6.6	0.04	5.1 -0.21
ANC	Cuba	23.9	30.8	37.7	0.66	28.7	-0.07	32.9	0.07	8.9 -0.71
Inpatient	Thai	5.7	6.2	6.7	0.75	5.9	-0.05	6.5	0.05	8.8 0.42
Day	S.Africa	29.3	30.6	31.8	0.86	29.7	-0.03	31.4	0.03	24.3 -0.21
Vaginal	Cuba	16.4	21.3	26.2	0.66	19.9	-0.07	22.8	0.07	7.6 -0.64
Delivery	Thai	20.6	23.1	25.5	0.75	21.9	-0.05	24.2	0.05	32.7 0.42
	S.Africa	74.5	81.4	88.3	0.88	79.5	-0.02	83.3	0.02	64.6 -0.21
Caesarean	Cuba	70.1	114.0	157.9	0.61	105.2	-0.08	122.8	0.08	48.9 -0.57
Section	Thai	52.08	74.4	96.7	n/a	n/a	n/a	n/a	n/a	105.5 0.42
	S.Africa	105.7	140.6	175.5	0.93	138.7	-0.01	142.5	0.01	111.6 -0.21
Postpartum	Cuba	13.9	16.8	19.6	0.65	15.6	-0.07	17.9	0.07	5.3 -0.68
Day	S.Africa	22.6	27.7	32.8	0.85	26.9	-0.03	28.5	0.03	22.0 -0.21
Neonatal	Cuba	96.7	118.1	139.5	0.63	109.4	-0.07	126.8	0.07	40.9 -0.65
Day	S.Africa	23.5	27.9	32.2	0.87	27.1	-0.03	28.6	0.03	22.1 -0.21

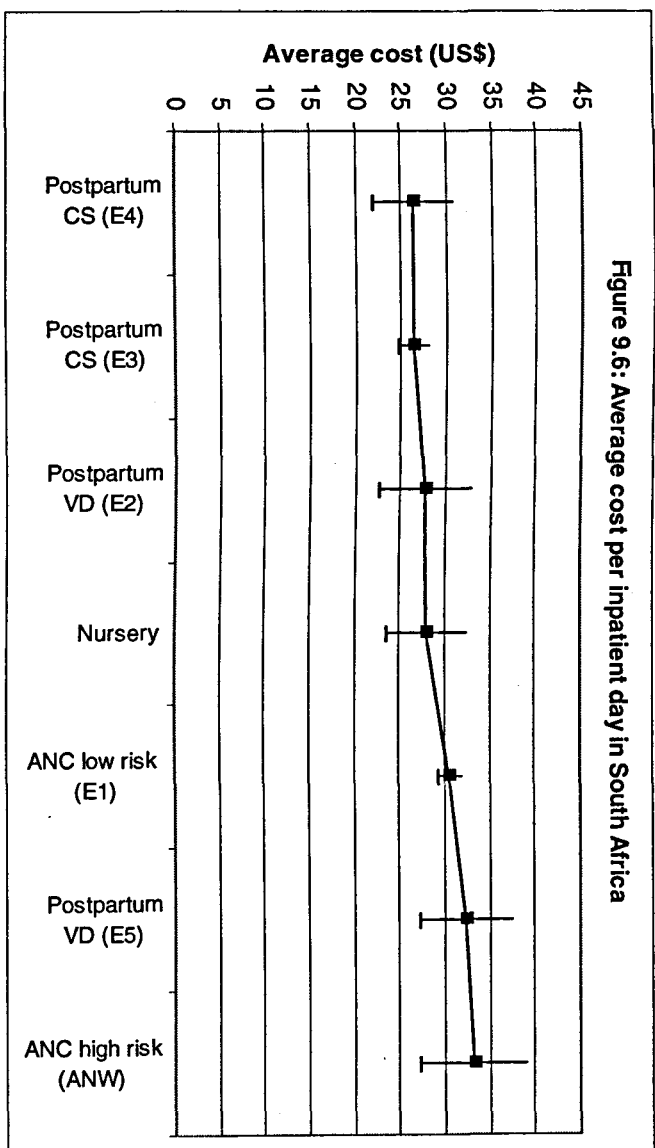
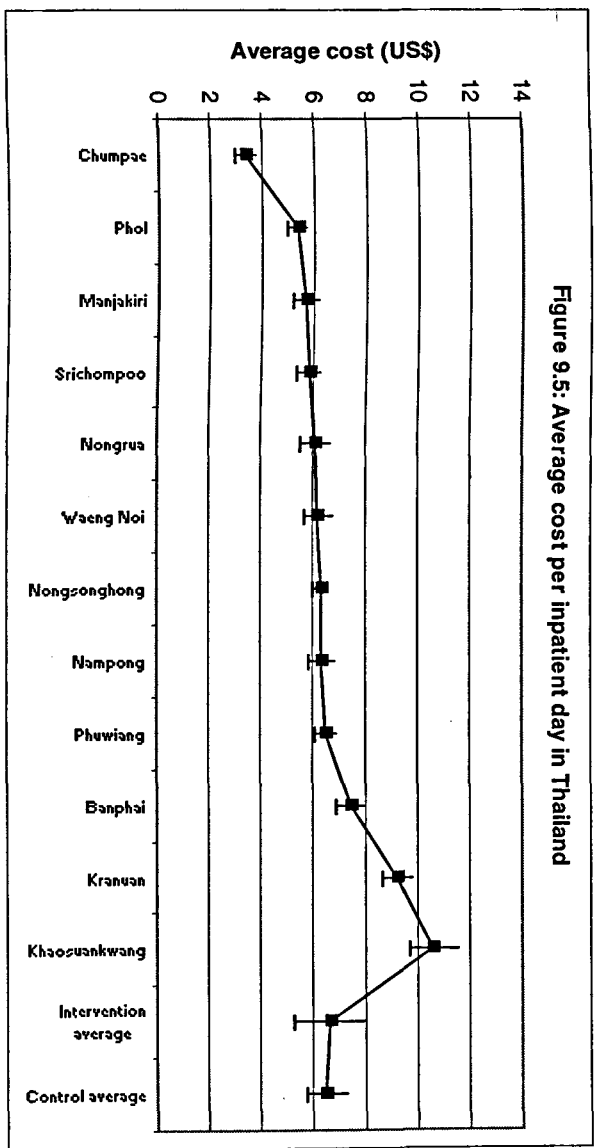
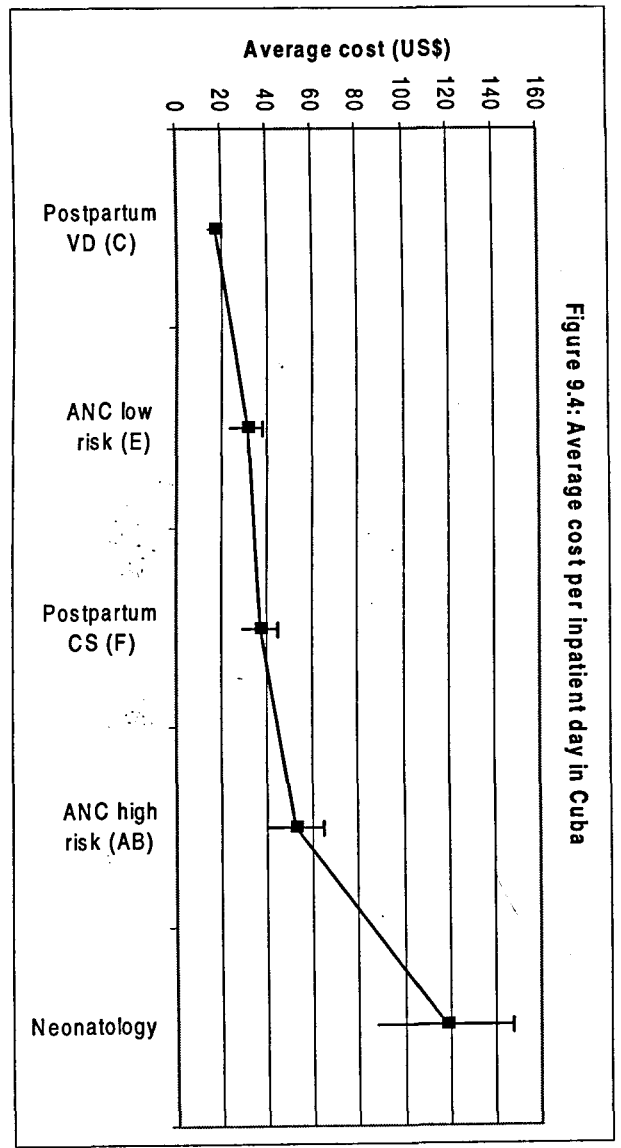
Figures in bold means that the AC range is larger than the lower or higher confidence limits

Table 9.13: Unit cost range taking into account small number of months.

Health care	Average cost (US\$)			Possible impact on average cost	
	Low	Base	High	AC range (US\$)	% difference with base average cost
Cuba					
Antenatal care	11.1	11.9	12.6	11.03 - 12.75	0.07
Inpatient care	23.9	30.8	37.7	28.32 - 33.58	0.08
Vaginal delivery	16.4	21.3	26.2	18.87 - 24.10	0.12
South Africa					
Antenatal care	4.2	6.4	8.5	5.86 - 6.92	0.08
Inpatient care	29.3	30.6	31.8	25.64 - 35.05	0.16*
Vaginal delivery	74.5	81.4	88.3	67.82 - 97.67	0.17*
Caesarean section	105.7	140.6	175.5	104.15 - 169.02	0.26*
Postpartum care	22.6	27.7	32.8	24.29 - 31.52	0.12
Neonatal care	23.5	27.9	32.2	23.44 - 33.09	0.16*

Figures in bold means that the AC range is larger than the lower or higher confidence limits





Appendix 10: Risk factors for patients in interventions arms in Cuba and Thailand**Table 10.1: Eligibility for the WHO ANC programme in Cuba - risk factors.**

Polyclinic	Number of women	Obstetric history							Current pregnancy		
		Previous Stillbirth	>2 abortion	Last <2500g	Last >4500g	Admission last preg.	Previous surgery	Multiple Pregnancy	<16 years	>40 years	Rh-
Albarran	631	13	2	12	9	26	11	2	2	1	6
Manduley	654	14	8	8	11	22	23	4	0	1	4
Romay	473	5	4	9	6	6	9	4	13	5	2
Galvan	521	14	2	24	10	11	19	4	2	2	4
Zulueta	446	9	7	18	10	17	15	5	2	1	1
13 de Marzo	527	15	10	7	6	8	9	1	4	1	3
ALL	3252	70	33	78	52	90	86	20	23	11	20
Polyclinic	Average cost	Current pregnancy			General medical					Eligibility	
		Vaginal Bleeding	Pelvic mass	DBP >90 mm Hg	IDDM	Renal disease	Cardiac disease	Substance Abuse	Other severe	No.	%
Albarran	11.86	32	25	16	1	9	5	10	90	171	0.27
Manduley	9.12	19	14	9	1	7	3	14	74	168	0.26
Romay	10.01	10	5	10	1	6	5	0	33	101	0.21
Galvan	18.36	12	11	7	1	12	4	0	65	148	0.28
Zulueta	11.46	32	2	6	2	2	1	1	9	114	0.26
13 de Marzo	12.27	16	8	9	0	4	7	2	70	137	0.26
ALL	12.18	121	65	57	6	40	25	27	341	839	0.26

Table 10.2: Eligibility for the WHO ANC programme in Thailand - risk factors.

District hospital	Number of women	Obstetric history							Current pregnancy		
		Previous stillbirth	<2 Abortion	Last <2500g	Last >4500g	Adm. last preg.	Previous surgery	Multiple pregnancy	<16 years	>40 years	Rh-
Chumpae	1064	3	2	35	0	0	13	0	11	7	0
Banphai	759	15	6	31	0		31	2	16	4	1
Puvieng	594	15	4	27	2	3	24	1	3	4	0
Manjakiri	493	6	0	23	0	1	5	0	2	3	0
KSK	320	1	0	8	0	0	2	0	5	1	1
Waeng Noi	219	3	0	4	1	0	3	0	2	3	0
ALL	3449	43	12	128	3	4	78	3	39	22	2
District hospital	Average cost	Current pregnancy			General medical					Eligibility	
		Vaginal bleeding	Pelvic Mass	DBP >90 mm Hg	IDDM	Renal disease	Cardiac disease	Substance abuse	Other severe	No.	%
Chumpae	5.39	1	1	0	1	0	0	0	20	91	0.09
Banphai	6.17	1	0	4	1	3	0	3	6	106	0.14
Puvieng	4.12	2	0	0	4	1	4	1	10	86	0.14
Manjakiri	6.42	31	0	1	0	2	2	0	3	75	0.15
KSK	8.56	0	0	0	0	0	0	0	4	22	0.07
Waeng Noi	6.12	0	0	0	1	0	0	0	2	16	0.07
ALL	5.80	35	1	5	7	6	6	4	45	396	0.11

Table 11.1: Comparison of resource prices in Cuba, Thailand and South Africa (US\$).

Name of material	Cost in 1998 (US\$)			Comparisons		
	Cuba	Thailand	South Africa	TH>CU	SA>CU	SA>TH
Alcohol (litre)	1.3	0.8		0.62		
Catheter (Foley's)		0.67	0.8			1.19
Detergent (litre)	1.89	0.52	1.28	0.28	0.68	2.46
Elastic Bandage 4" (dozen)		7.07	14.21			2.01
Garbage bags (roll)		0.96	1.1			1.15
Gauze swabs (box)	1.6	1.43	1.58	0.89	0.99	1.10
Gloves (box of disposable)		2.29	3.73			1.63
Gloves (surgical)		4.21	6.97			1.66
Needle (box of disposable)		1.4	2.49			1.78
Plaster 2" (box)		4.65	5			1.08
Soap (bar)	0.53	0.13	0.1	0.25	0.19	0.77
Toilet paper (roll)		0.08	0.22			2.75
Washing liquid (litre)	2.16	3.25	3.55	1.50	1.64	1.09
	Average ratio			0.71	0.87	1.56
Name of drug	Cost in 1998 (US\$)			Comparisons		
	Cuba	Thailand	South Africa	TH>CU	SA>CU	SA>TH
Adrenaline		0.2	0.16			0.80
TT (dose)	0.4	0.6		1.50		
Vit C (pill)	0.13	0.02		0.15		
Multi-vitamins (pill)	0.056	0.091	0.017	1.63	0.30	0.19
Paracetamol (500mg pill)	0.02	0.01	0.0048	0.50	0.24	0.48
Folic acid (5mg pill)	0.03	0.0048	0.008	0.16	0.27	1.67
Amoxyl (250 mg pill)		0.0573	0.0327			0.57
Diazepam (500mg 100 pill)	6	1.91		0.32		
Vitamina B1 (10mg, 100 pill)	0.10	0.02		0.20		
Vitamin B complete (pill)		0.0096	0.00242			0.25
Erythromycin (125mg, 100ml)		0.87	0.92			1.06
Ferrous sulphate (pills)		0.00956	0.0039			0.41
Magnesium sulphate (75g powder)		0.19	0.03			0.16
Pennicilin (250mg pill)		0.019	0.016			0.84
Vitamin K (10mg, infection)		0.48	1.25			2.60
Clotrimazol (pill)	0.2	0.01		0.05		
Metronidazol (pill)	0.075	0.01	0.0066	0.13	0.09	0.66
Benzatinica (inj)	1.5	1.91		1.27		
Theophyllin (200mg pill)		0.057	0.019			0.33
	Average ratio			0.59	0.22	0.77

Table 11.1: Comparison of resource prices in Cuba, Thailand and South Africa (US\$).

Member of staff (job description)	Gross salary per month (US\$)			Comparisons		
	Cuba	Thailand	South Africa	TH>CU	SA>CU	SA>TH
Head of HCPU (hospital)	500	642	4'566	1.28	9.13	7.12
Head of HCPU (clinic)	450	642	1'175	1.43	2.61	1.83
Specialist	450	765	3'145	1.70	6.99	4.11
Doctor	350	478	2'000	1.37	5.71	4.18
Senior nurse	298	397	1'100	1.33	3.69	2.77
Professional nurse	250	286	800	1.14	3.20	2.80
Enrolled/empirical nurse	200	230	600	1.15	3.00	2.61
Science technician	211	256	1'173	1.21	5.56	4.58
Radiologist	211	268	1'300	1.27	6.16	4.86
Pharmacist	198	325	1'000	1.64	5.05	3.08
Accountant	170	248	1'000	1.46	5.88	4.03
Typist	170	172	700	1.01	4.12	4.07
Clerk	128	191	900	1.49	7.03	4.71
Security guard	126	150	600	1.19	4.76	4.00
Driver	110	134	600	1.22	5.45	4.48
Cleaner	100	120	450	1.20	4.50	3.75
AVERAGE	261.47	353.54	1'407.27	1.41	5.52	4.20
Item of equipment	Cost in 1998 (US\$)			Comparisons		
	Cuba	Thailand	South Africa	TH>CU	SA>CU	SA>TH
Machinery/electrical						
Autoclave	2117	3400	10'000	1.61	4.72	2.94
Centrifuge	846	726	1670	0.86	1.97	2.30
Computer	2000	765	1560	0.38	0.78	2.04
ECG machine (8 channel)	6960	2868	3'600	0.41	0.52	1.26
Fridge (food, large)	700	250	400	0.36	0.57	1.60
Incubator (ICU, premature)	7200	3060	26'000	0.43	3.61	8.50
Microscope	3866	1920	5'000	0.50	1.29	2.60
Photocopier	2700	1720	1'100	0.64	0.41	0.64
Type writer (electric)	336	573	600	1.71	1.79	1.05
AVERAGE	26725	15282	49'930	0.76	1.74	2.55
Non-machinery						
Bed (fowler)	83	192	165	2.31	1.99	0.86
Cabinet (4 drawer filing, steel)	124	66	42	0.53	0.34	0.64
Case (book)	124	115	143	0.93	1.15	1.24
Chair (arm)	80	29	75	0.36	0.94	2.59
Chair (normal)	8	7	13	0.88	1.63	1.86
Clock (wall)	30	15	32	0.50	1.07	2.13
Desk (office)	39	25	68	0.64	1.74	2.72
Scales & height measure	100	191	203	1.91	2.03	1.06
Scales (baby)	30	17	165	0.57	5.50	9.71
Table (office)	62	29	53	0.47	0.85	1.83
Trolley (medicine)	100	97	130	0.97	1.30	1.34
AVERAGE	780	783	1089	0.92	1.69	2.36

Appendix 12: Cost per pregnancy results in study countries**Table 12.1: Percent contributors to cost per pregnancy, by type of care and resource ingredient.**

Country, trial arm and health facility	Cases		Health care type (%)					Resource ingredient (%)					
	No.	%	OP	IP	DEL	PP	NN	ST	EQ	MA	DR	UT	BU
CUBA													
13 de Marzo	449	8.0	0.24	0.22	0.11	0.25	0.19	0.58	0.03	0.11	0.20	0.05	0.04
Albarran	567	10.1	0.25	0.19	0.11	0.22	0.23	0.64	0.03	0.10	0.19	0.03	0.01
Galvan	459	8.2	0.26	0.17	0.09	0.21	0.27	0.60	0.03	0.10	0.21	0.04	0.02
Manduley	575	10.3	0.21	0.21	0.14	0.27	0.18	0.61	0.03	0.12	0.19	0.04	0.02
Romay	418	7.5	0.20	0.20	0.12	0.24	0.24	0.63	0.03	0.12	0.16	0.05	0.01
Zulueta	402	7.2	0.27	0.14	0.14	0.28	0.17	0.56	0.03	0.11	0.24	0.04	0.02
<i>Average Intervention</i>	2870	51.2	0.24	0.19	0.11	0.24	0.22	0.60	0.03	0.11	0.20	0.04	0.02
Aballi	514	9.2	0.39	0.14	0.10	0.21	0.15	0.65	0.02	0.08	0.19	0.03	0.02
Escalona	628	11.2	0.27	0.17	0.11	0.22	0.24	0.58	0.03	0.10	0.21	0.04	0.04
Guiteras	177	3.2	0.49	0.07	0.09	0.18	0.17	0.70	0.03	0.07	0.15	0.04	0.01
Reina	648	11.6	0.41	0.13	0.11	0.22	0.13	0.62	0.03	0.08	0.20	0.04	0.03
Tamayo	294	5.2	0.42	0.08	0.10	0.20	0.20	0.65	0.02	0.08	0.20	0.03	0.02
Vantroi	473	8.4	0.29	0.14	0.12	0.25	0.21	0.58	0.03	0.10	0.22	0.05	0.02
<i>Average control</i>	2734	48.8	0.36	0.13	0.11	0.22	0.18	0.63	0.03	0.09	0.19	0.04	0.02
AVERAGE ALL	5604	100	0.30	0.16	0.11	0.23	0.20	0.61	0.03	0.10	0.20	0.04	0.02
THAILAND													
Chumpae	1001	15.7	0.34	0.01	0.28	0.34	0.03	0.72	0.04	0.11	0.09	0.01	0.02
Banphai	729	11.4	0.25	0.00	0.38	0.31	0.05	0.76	0.06	0.08	0.06	0.00	0.03
Phuwiang	558	8.8	0.34	0.01	0.41	0.24	0.01	0.58	0.05	0.28	0.03	0.01	0.05
Manjakiri	476	7.5	0.39	0.01	0.42	0.18	0.01	0.70	0.07	0.07	0.11	0.02	0.04
Khaosuankwang	306	4.8	0.38	0.03	0.27	0.31	0.01	0.57	0.12	0.11	0.14	0.00	0.05
Waeng Noi	208	3.3	0.26	0.00	0.47	0.25	0.02	0.64	0.14	0.11	0.03	0.02	0.06
<i>Intervention average</i>	3278	51.5	0.32	0.01	0.36	0.29	0.03	0.66	0.08	0.13	0.08	0.01	0.04
Kranuan	821	12.9	0.52	0.01	0.24	0.22	0.01	0.61	0.06	0.18	0.11	0.04	0.02
Nongsonghong	323	5.1	0.28	0.01	0.29	0.38	0.04	0.65	0.11	0.02	0.11	0.03	0.08
Phol	630	9.9	0.39	0.01	0.28	0.29	0.03	0.77	0.03	0.07	0.09	0.01	0.02
Nongrua	400	6.3	0.28	0.00	0.36	0.35	0.01	0.70	0.09	0.07	0.07	0.01	0.07
Srichompoo	595	9.3	0.53	0.00	0.35	0.11	0.01	0.60	0.07	0.12	0.17	0.00	0.04
Nampong	322	5.1	0.44	0.02	0.26	0.23	0.05	0.72	0.07	0.11	0.04	0.03	0.02
<i>Control average</i>	3091	48.5	0.42	0.01	0.29	0.26	0.02	0.67	0.07	0.09	0.10	0.02	0.04
AVERAGE ALL	6369	100	0.37	0.01	0.32	0.27	0.02	0.67	0.08	0.11	0.09	0.02	0.04
SOUTH AFRICA													
Prince Mshiyeni	785	100	0.17	0.11	0.38	0.25	0.10	0.76	0.01	0.08	0.04	0.05	0.06

Key: OP – outpatient care; IP – inpatient care during pregnancy; DEL – delivery care; PP – postpartum care; NN – neonatal care; St – staff cost; EQ – equipment cost; MA – material cost; DR – drug cost; UT – utility cost; BU – building cost.

Table 12.2: US\$ contributors to cost per pregnancy, by type of care and resource ingredient.

Country, trial arm and health facility	Cases		Health care type (%)					Resource ingredient (%)					
	No.	%	OP	IP	DEL	PP	NN	ST	EQ	MA	DR	UT	BU
CUBA													
13 de Marzo	449	8.0	90.5	83.13	42.56	93.79	72.48	223.5	10.96	40.63	76.38	17.27	13.66
Albarran	567	10.1	91.0	66.58	38.32	80.37	81.02	227.9	9.73	36.74	66.41	11.94	4.56
Galvan	459	8.2	131.0	84.86	45.14	104.6	138.7	301.1	13.08	51.97	107.3	21.75	9.24
Manduley	575	10.3	68.2	67.44	44.57	88.15	57.46	197.3	10.48	38.57	60.61	13.07	5.75
Romay	418	7.5	73.4	74.84	43.49	88.55	88.99	232.3	11.17	43.20	59.99	17.45	5.10
Zuluetta	402	7.2	81.8	41.73	40.68	84.25	49.65	167.2	8.20	32.44	72.56	12.16	5.53
<i>Average Intervention</i>	2870	51.2	88.9	69.99	42.41	89.65	80.94	223.6	10.49	39.85	75.25	15.29	7.40
Aballi	514	9.2	162.7	59.47	42.41	90.04	65.02	273.5	10.29	34.57	79.93	14.37	7.00
Escalona	628	11.2	106.8	66.31	43.90	89.02	95.34	231.3	12.81	40.29	83.07	15.89	17.98
Guiteras	177	3.2	218.3	32.01	40.61	79.95	76.35	311.9	11.33	32.30	68.69	18.37	4.57
Reina	648	11.6	156.4	48.02	43.20	84.76	49.57	236.7	11.22	31.74	77.24	15.45	9.62
Tamayo	294	5.2	186.8	35.74	42.57	87.30	89.68	288.5	9.90	33.91	86.72	14.82	8.16
Vantroi	473	8.4	107.3	50.53	42.48	91.85	76.65	214.5	9.58	37.07	82.26	16.64	8.69
<i>Average control</i>	2734	48.8	145.0	52.42	42.85	87.91	73.72	251.6	10.99	36.19	77.64	15.98	9.50
AVERAGE ALL	5604	100	116.3	61.41	42.62	88.80	77.42	236.7	10.74	38.42	76.70	15.65	8.35
THAILAND													
Chumpae	1001	15.7	23.14	0.89	19.06	23.07	2.21	49.1	2.73	7.57	6.46	0.94	1.56
Banphai	729	11.4	29.51	0.40	44.26	36.37	5.35	88.5	7.10	9.36	7.02	0.02	2.93
Phuwiang	558	8.8	21.80	0.56	26.50	15.46	0.76	37.5	3.51	18.23	2.24	0.59	3.03
Manjakiri	476	7.5	30.19	0.64	32.39	13.76	0.80	54.2	5.20	5.66	8.41	1.43	2.86
Khaosuankwang	306	4.8	38.57	2.54	27.22	31.56	0.92	57.8	12.47	11.01	13.77	0.44	5.30
Waeng Noi	208	3.3	29.66	0.54	54.08	27.91	1.71	73.4	15.64	12.04	3.77	2.75	6.34
<i>Intervention average</i>	3278	51.5	27.21	0.82	30.85	24.48	2.31	56.8	6.75	10.74	6.84	1.02	3.35
Kranuan	821	12.9	55.07	1.25	25.95	22.97	1.07	64.6	6.71	19.55	11.33	4.14	2.22
Nongsonghong	323	5.1	24.26	0.67	25.69	32.73	3.92	56.4	9.93	1.99	9.25	2.70	6.99
Phol	630	9.9	52.99	1.61	37.57	40.11	3.86	105.4	4.53	9.97	11.90	1.27	3.03
Nongrua	400	6.3	31.82	0.21	41.08	39.83	1.59	79.9	9.96	8.27	7.74	1.19	7.47
Srichompoo	595	9.3	36.97	0.00	24.34	7.33	0.73	41.6	4.86	8.09	12.07	0.32	2.45
Nampong	322	5.1	51.91	2.15	30.40	27.28	5.76	85.1	8.36	12.60	4.65	3.91	2.91
<i>Control average</i>	3091	48.5	44.60	0.98	30.40	27.10	2.43	70.8	7.75	10.01	10.68	2.25	4.41
AVERAGE ALL	6369	100	35.65	0.90	30.63	25.75	2.36	63.8	7.19	10.22	8.73	1.61	3.87
SOUTH AFRICA													
Prince Mshiyeni	785	100	60.03	38.17	130.8	86.75	34.70	264.9	4.78	28.62	13.31	15.87	19.53

Key: OP – outpatient care; IP – inpatient care during pregnancy; DEL – delivery care; PP – postpartum care; NN – neonatal care; St – staff cost; EQ – equipment cost; MA – material cost; DR – drug cost; UT – utility cost; BU – building cost.

Appendix 13: Cost per pregnancy and sub-group analysis**Table 13.1: Summary of mean differences between categories of women in Cuba**

RISK FACTORS or EVENTS INFLUENCING COST PER PREGNANCY	Cost category (presented in US\$)					Total
	Antenatal care		Delivery care	Postpartum care		
	OP	IP		Woman	Baby	
Previous pregnancy (-ies)						
First pregnancy	4	0	3	0	38	45
Previous stillbirth or neonatal loss	43	15	12	20	80	170
3 or more previous spontaneous abortions	0	-4	0	-9	-7	-20
Last baby LBW	40	-20	1	5	30	56
Admission for HDP in last pregnancy	30	53	2	5	30	120
Previous reproductive tract surgery	32	82	45	72	25	256
Events this pregnancy and delivery						
Referred to a higher level	18	263	19	60	78	441
Hospital admission during pregnancy	2	450	15	50	143	660
Adverse pregnancy event (*)	8	35	5	0	0	48
Prelabour rupture of membranes	-5	10	-16	-7	34	16
Induced labour	11	111	19	37	14	192
Elective caesarean section	7	75	93	157	48	380
Postpartum information						
LBW baby	-11	175	5	100	782	1052
Pre-term infant	-20	128	2	73	800	983
Post-term infant	6	69	9	132	-11	87
Congenital malformation	-39	-10	-15	-20	74	10

TABLE KEY: In bold: means the figure is statistically significant ($p < 0.05$); (*) includes sexually transmitted diseases, urinary tract infection, hypertensive diseases of pregnancy, anemia and bleeding.

Table 13.2: Summary of mean differences between categories of women in Thailand

RISK FACTORS or EVENTS INFLUENCING COST PER PREGNANCY	Cost category					Total
	Antenatal care		Delivery care	Postpartum care		
	OP	IP		Woman	Baby	
Previous pregnancy (-ies)						
First pregnancy	2	0	0	2	0	4
3 or more previous spontaneous abortions	2	0	1	9	1	13
Previous reproductive tract surgery	2	5	17	70	2	96
Events this pregnancy and delivery						
Referred to a higher level	12	14	-6	9	0	29
Hospital admission during pregnancy	4	13	0	9	13	39
Adverse pregnancy event (*)	4	3	3	-6	7	-11
Prelabour rupture of membranes	3	2	3	10	7	25
Adverse diagnosis at admission to labour	4	5	7	38	13	65
Induced labour	10	3	5	24	3	45
Elective caesarean section	6	5	24	68	15	119
Postpartum information						
LBW baby	-7	0	1	6	18	18
Pre-term infant	-7	2	-4	-5	22	8
Post-term infant	8	0	4	-2	-1	9
Postpartum syphilis	-1	-2	11	30	-2	36

TABLE KEY: In bold: means the figure is statistically significant ($p < 0.05$); (*) includes sexually transmitted diseases, urinary tract infection, hypertensive disorders of pregnancy, anemia and bleeding.

Table 13.3: Summary of mean differences between categories of women in South Africa

RISK FACTORS or EVENTS INFLUENCING COST PER PREGNANCY	Cost category					Total
	Antenatal care		Delivery care	Postpartum care		
	OP	IP		Woman	Baby	
Previous pregnancy (-ies)						
First pregnancy	7	16	1	3	-11	16
3 or more previous spontaneous abortions	-4	19	1	-16	-2	-2
Admission for HDP in last pregnancy	3	37	33	83	1	157
Previous reproductive tract surgery	0	-16	-5	0	-6	-27
Events this pregnancy and delivery						
Referred to a higher level	14	81	14	42	12	163
Hospital admission during pregnancy	10	138	12	35	5	200
Adverse pregnancy event (*)	8	65	3	22	0	97
Prelabour rupture of membranes	0	-48	4	3	13	-27
Adverse diagnosis at admission to labour	2	85	6	19	-5	107
Induced labour	-3	102	2	7	3	111
Elective caesarean section	10	184	49	108	61	413
Postpartum information						
Pre-term infant	14	68	-4	-3	61	136
Post-term infant	33	15	16	2	6	62
Congenital malformation	4	2	6	120	20	152
Postpartum syphilis	7	4	10	78	31	130

TABLE KEY: In bold: means the figure is statistically significant ($p < 0.05$); (*) includes sexually transmitted diseases, urinary tract infection, hypertensive disorders of pregnancy, anemia and bleeding.

Table 13.1: Differences between cost for women with different risks or event status in Cuba.

VARIABLES	Arm	Detail	N	Outpatient ANC			Inpatient ANC			Delivery care			Postpartum care			Neonatal care			All care		
				Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High
Overall																					
CONTROL			2559	139	140	141	50	54	58	42	43	44	87	88	90	65	74	82	388	399	410
INTERVENTION			3050	95	96	97	63	68	73	42	42	43	87	89	91	72	81	89	364	376	389
ALL WOMEN			5609	116	116	117	58	61	65	42	43	43	87	89	90	71	77	83	378	387	395
Risk																					
Age	C	<16	12	109	118	126	0	21	41	21	29	37	109	147	186	448	1043	1638	765	1358	1951
		16-40	2538	139	140	141	49	53	57	42	43	44	86	88	90	61	68	76	383	393	403
		>40	9	110	125	141	101	302	502	28	42	56	34	59	84	0	236	472	472	764	1055
	I	<16	24	112	122	133	26	221	416	27	33	39	60	74	87	25	69	113	314	519	723
		16-40	3012	95	96	97	62	66	71	42	42	43	87	89	91	72	81	89	362	375	387
		>40	14	128	141	155	39	106	173	42	54	67	60	79	98	0	84	169	333	465	597
Number of pregnancy	C	First	469	136	138	140	46	55	64	38	40	42	88	92	97	91	117	142	413	443	472
		> First	2090	139	140	141	49	54	58	43	44	45	85	88	90	55	64	72	378	389	400
	I	First	568	90	92	94	70	84	98	38	40	41	86	91	96	76	101	126	374	408	442
		> First	2482	96	97	99	59	64	69	42	43	44	87	89	91	67	76	85	356	369	382
Previous stillbirth	C	No	2497	139	139	140	49	53	57	42	43	44	86	88	90	63	71	79	384	395	405
		Yes	61	152	158	164	63	88	114	43	49	54	90	103	116	89	174	259	479	573	667
	I	No	2986	94	95	96	62	67	73	41	42	43	87	89	90	69	77	85	358	370	382
		Yes	64	152	158	165	52	83	113	42	47	53	96	112	129	125	255	384	500	655	809
Previous abortion	C	No	759	137	139	140	51	58	66	41	43	44	90	93	97	76	94	112	405	427	449
		Yes	1799	139	140	141	47	52	57	42	43	44	84	86	89	56	65	74	375	387	399
	I	No	957	95	96	98	61	70	80	42	43	44	92	96	101	63	79	95	363	385	408
		Yes	2093	95	96	98	61	67	72	41	42	43	84	86	88	71	81	92	358	372	387
Last baby <2500g	C	No	2040	139	140	141	50	55	59	43	44	45	85	87	89	56	65	73	378	390	402
		Yes	51	156	163	170	0	4	8	39	45	51	83	96	109	6	35	63	308	343	378
	I	No	2439	95	96	98	59	65	70	42	43	44	86	89	91	68	76	85	356	369	382
		Yes	43	139	148	156	15	33	52	39	45	51	74	92	110	11	49	87	297	367	438
Previous admission	C	No	1983	139	140	141	49	53	58	43	43	44	84	86	88	54	63	72	374	386	397
		Yes	21	159	171	183	37	70	104	31	39	47	72	96	119	0	34	67	337	410	483
	I	No	2280	95	96	97	58	58	58	43	43	43	88	88	88	67	77	86	347	361	374
		Yes	76	134	139	145	76	121	165	42	45	47	82	98	113	52	109	166	438	511	584
Previous RT surgery	C	No	2062	139	140	141	48	53	58	42	43	44	84	86	88	55	64	72	375	386	398
		Yes	25	149	158	166	42	97	153	101	107	112	163	184	206	28	71	114	533	617	701
	I	No	2388	94	96	97	56	61	66	40	41	42	84	86	88	66	75	84	346	359	371
		Yes	95	140	145	151	104	150	195	77	82	86	139	152	165	49	102	155	540	631	721

Table 13.1: Differences between cost for women with different risks or event status in Cuba.

VARIABLES	Arm	Detail	N	Outpatient ANC			Inpatient ANC			Delivery care			Postpartum care			Neonatal care			All care		
				Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High
ANC and pregnancy events																					
First visit (weeks)	C	<12	1870	143	144	145	46	50	55	42	43	44	83	85	87	53	63	72	372	384	397
		12 to 15	595	132	133	135	54	63	72	43	44	46	91	97	102	81	100	118	412	437	462
		16 to 20	66	108	112	116	57	84	111	35	40	44	83	95	106	57	115	172	374	445	515
		>20	28	75	81	87	3	25	47	40	48	56	91	116	142	68	156	244	314	427	540
	I	<12	2108	97	98	99	61	67	73	42	43	43	86	88	91	62	70	79	353	366	379
		12 to 15	771	94	96	97	59	70	81	41	43	44	88	92	96	74	91	108	365	391	418
		16 to 20	122	84	88	93	60	82	103	38	41	45	78	86	93	67	157	246	356	453	551
		>20	49	63	69	75	4	17	30	27	31	35	59	79	99	39	178	318	217	375	532
Refer to higher level	C	No	2396	138	139	140	35	38	42	41	42	42	83	85	87	58	66	74	360	370	381
		Yes	162	146	150	153	247	279	311	59	63	66	130	140	150	113	163	214	726	794	863
	I	No	2842	94	95	96	44	49	53	40	41	42	83	85	86	68	76	85	333	345	357
		Yes	208	117	121	125	291	329	367	56	60	63	137	149	161	102	140	179	727	799	871
Hospital admission	C	No	2230	139	140	141	0	1	2	40	41	42	81	83	85	53	61	69	317	326	335
		Yes	329	135	137	139	389	412	435	55	58	60	119	127	135	124	159	195	843	894	945
	I	No	2618	94	95	96	0	0	0	40	40	41	80	81	83	49	56	63	264	272	280
		Yes	432	103	106	109	450	478	506	52	55	57	128	136	144	190	232	274	943	1006	1070
Event in pregnancy	C	No	1163	136	138	139	26	30	33	41	42	43	83	85	88	53	64	75	345	358	371
		Yes	1396	141	142	143	67	74	81	43	44	45	88	91	94	70	82	94	417	433	450
	I	No	1406	90	91	92	46	53	60	42	43	44	87	90	93	73	86	98	345	362	380
		Yes	1644	100	101	102	73	80	88	41	42	43	86	88	91	65	76	88	371	388	405
Prelabour rupture	C	No	1914	140	141	142	54	59	64	42	43	44	86	89	91	56	65	74	385	397	410
		Yes	645	136	138	139	32	37	43	40	42	44	84	88	92	80	98	117	380	403	426
	I	No	2282	97	98	99	63	68	74	42	42	43	87	89	91	63	72	81	356	370	383
		Yes	768	89	91	93	56	66	76	41	42	43	86	90	94	87	106	126	367	395	423
Delivery and postpartum																					
Adverse diagnosis at	C	No	2065	137	138	139	25	28	31	37	37	38	74	76	77	52	61	69	330	340	349
admission to labour		Yes	494	147	149	151	146	161	177	64	66	68	137	143	149	104	128	152	611	647	682
	I	No	2417	91	92	93	21	24	26	37	37	38	75	77	79	49	56	64	277	287	296
		Yes	633	110	112	114	215	236	257	59	61	63	130	136	141	144	173	203	674	718	762
Labour ⁱ	C	Spont	1839	139	140	141	25	29	32	30	31	31	65	67	68	55	65	75	320	331	342
		Induced	456	140	142	144	116	128	141	50	52	54	99	105	110	71	89	108	489	517	545
		Elective CS	264	133	136	138	82	101	120	112	113	114	205	213	222	77	105	133	624	667	710
	I	Spont	2158	93	95	96	30	34	38	29	30	31	65	67	68	59	70	80	282	295	308
		Induced	547	95	97	99	138	154	170	45	47	48	98	102	107	73	93	113	461	493	525
		Elective CS	344	104	107	110	118	144	170	112	112	113	201	208	216	104	131	158	657	703	748

Table 13.1: Differences between cost for women with different risks or event status in Cuba.

VARIABLES	Arm	Detail	N	Outpatient ANC			Inpatient ANC			Delivery care			Postpartum care			Neonatal care			All care		
				Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High
Postpartum anaemia	C	No	2298	139	140	141	49	53	58	43	43	44	86	88	90	64	74	83	387	398	410
		Yes	259	136	138	140	47	59	70	38	40	42	85	91	96	56	74	92	376	401	427
	I	No	2762	95	96	97	62	67	72	42	43	43	87	89	91	75	84	93	366	379	392
		Yes	285	93	97	100	59	74	89	37	39	41	82	89	95	34	49	63	315	347	379
Postpartum syphilis	C	No	2507	139	140	141	50	55	59	42	43	44	87	89	91	66	74	83	390	401	412
		Yes	50	135	141	147	11	20	30	35	40	45	66	76	85	9	31	53	269	308	346
	I	No	2960	95	96	97	62	67	72	42	42	43	86	88	90	69	77	86	360	372	384
		Yes	88	93	99	105	45	80	116	37	41	45	100	119	138	70	191	311	392	530	669
Mode of delivery	C	Spont	1877	138	139	140	32	36	40	21	21	21	48	49	50	59	70	80	303	315	327
		Elective CS	269	134	137	139	80	98	117	114	114	114	205	213	221	66	94	121	613	655	697
		Intra CS	330	143	145	148	97	112	126	114	114	114	207	213	219	65	82	98	639	665	692
		Forceps	79	145	149	154	57	92	127	21	21	21	71	78	86	42	69	96	361	410	458
		Ass breech	4	170	188	206	0	0	0	21	21	21	50	50	50	0	0	0	241	260	278
		Ass breech	2268	93	94	95	40	44	49	21	21	21	51	52	53	51	60	68	260	271	283
	I	Spont	346	104	107	110	107	129	151	114	114	114	202	209	216	100	127	153	643	686	729
		Elective CS	344	94	97	100	129	154	179	114	114	114	212	219	226	89	117	146	656	702	748
		Intra CS	89	101	108	114	74	94	114	21	21	21	64	69	75	169	300	431	458	592	726
		Forceps	2	95	181	268	0	0	0	21	21	21	50	50	50	0	0	0	166	253	339
		Ass breech	180	120	123	127	117	148	178	41	44	47	164	180	196	663	761	859	1140	1256	1372
		Ass breech	2366	140	141	142	43	47	50	42	43	44	80	82	83	19	22	25	328	334	340
Birth weight	C	LBW	223	88	92	96	238	284	330	47	50	53	169	184	199	738	838	937	1321	1452	1583
		NBW	2811	96	97	98	47	50	54	41	42	42	80	81	83	18	21	23	285	291	297
	I	LBW	128	104	108	112	102	139	175	35	39	42	139	157	174	671	797	923	1097	1239	1381
		NBW	2259	140	141	142	40	44	48	42	42	43	81	83	85	31	36	41	339	347	355
Gest age at birth	C	Preterm	172	145	148	151	100	116	132	52	55	59	100	107	114	17	25	34	428	451	474
		Normal	178	83	88	92	164	207	250	41	44	47	140	157	174	738	858	979	1209	1361	1513
		Post-term	2669	95	97	98	50	54	59	41	42	43	83	84	86	30	33	37	302	310	318
	I	Preterm	203	99	103	107	98	121	144	45	48	51	86	92	98	9	19	29	355	383	411
		Normal	2543	139	140	141	50	54	58	42	43	44	87	89	91	65	73	81	388	399	410
		Post-term	15	74	84	94	0	43	86	25	34	42	46	70	95	8	181	354	209	412	615
Congen malform	C	No	3034	96	97	98	63	68	73	42	42	43	87	89	91	72	81	89	364	377	389
		Yes	10	58	69	80	16	55	93	21	21	21	49	65	82	43	165	288	234	376	517
	I	No																			
		Yes																			

Table 13.2: Differences between cost for women with different risks or event status in Thailand.

VARIABLE	Arm	Detail	N	Outpatient ANC			Inpatient ANC			Delivery care			Postpartum care			Neonatal care			All care		
				Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High
Overall																					
CONTROL			3112	39	39	39	1	1	1	32	32	32	39	41	43	1	1	2	111	114	116
INTERVENTION			3197	38	39	39	1	1	1	37	38	38	66	69	71	3	3	4	146	150	153
ALL WOMEN			6369	39	39	39	1	1	1	34	35	35	53	55	56	2	2	3	130	132	134
Risk																					
Number of pregnancy	C	First	1328	38	39	39	1	1	1	31	32	32	35	38	41	1	3	4	108	112	115
		> First	1844	38	39	39	1	1	1	32	32	33	40	42	45	1	1	1	112	115	118
	I	First	1277	39	40	41	1	1	1	37	38	39	67	71	75	3	4	5	150	155	160
		> First	1920	37	38	38	1	1	1	36	37	38	64	67	70	2	3	3	142	146	150
Previous stillbirth	C	No	1786	38	39	39	1	1	1	37	38	38	66	69	72	3	3	3	146	150	153
		Yes	59	40	43	46	1	1	2	29	32	35	24	37	50	0	1	2	97	114	130
	I	No	1859	37	38	38	1	1	1	36	37	38	63	66	69	2	3	3	140	144	148
		Yes	62	37	40	43	0	3	7	35	39	43	83	104	126	5	10	15	168	197	226
Previous abortion	C	No	1341	38	39	39	1	1	1	31	31	32	33	36	39	0	1	1	103	107	110
		Yes	504	39	40	41	1	1	1	34	35	36	53	59	66	1	1	1	129	136	144
	I	No	1458	37	37	38	1	1	1	36	36	37	60	63	66	2	3	4	136	140	145
		Yes	463	38	39	40	1	2	3	38	40	41	74	81	88	2	3	4	156	164	173
Last baby <2500g	C	No	1695	39	39	40	1	1	1	32	32	33	41	43	46	1	1	1	113	116	120
		Yes	150	33	34	36	0	1	1	29	30	32	22	31	40	0	1	1	86	97	107
	I	No	1811	37	38	38	1	1	1	36	37	38	64	67	70	2	2	3	141	145	149
		Yes	111	33	35	37	0	1	2	34	37	39	60	78	96	4	8	12	138	159	180
Previous RT surgery	C	No	3140	38	39	39	1	1	1	31	32	32	38	40	42	1	1	2	110	113	115
		Yes	32	41	45	49	1	8	14	49	53	58	82	106	131	1	2	4	185	214	244
	I	No	3168	38	39	39	1	1	1	37	38	38	65	68	70	3	3	4	145	148	151
		Yes	29	31	35	39	0	4	7	46	52	57	155	187	220	2	4	6	245	282	320
ANC and pregnancy events																					
First visit (weeks)	C	<12	1006	43	44	45	1	1	1	32	33	33	43	47	51	1	1	1	120	125	130
		12 to 15	786	40	41	42	1	1	2	31	32	33	38	42	46	1	2	4	114	119	124
		16 to 20	613	36	36	37	0	1	1	31	32	33	38	42	46	1	2	3	107	113	118
		>20	767	31	32	32	0	0	0	30	31	31	26	29	33	0	1	1	89	93	97
	I	<12	786	41	42	43	1	2	2	38	39	41	71	76	81	2	3	5	156	163	169
		12 to 15	748	37	38	39	1	1	2	37	38	39	68	73	78	2	3	5	147	154	161
		16 to 20	635	35	36	36	0	0	1	36	38	39	63	68	73	1	2	4	137	144	150
		>20	1028	37	38	39	0	1	1	35	36	37	57	61	65	3	4	5	135	140	145

Table 13.2: Differences between cost for women with different risks or event status in Thailand.

VARIABLE	Arm	Detail	N	Outpatient ANC			Inpatient ANC			Delivery care			Postpartum care			Neonatal care			All care		
				Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High
Refer to higher level	C	No	3106	38	38	39	0	0	1	32	32	32	39	41	43	1	1	2	111	114	116
		Yes	66	54	56	59	11	14	17	25	27	29	11	12	14	0	1	1	105	110	115
	I	No	3117	38	39	39	0	1	1	37	38	38	66	68	71	3	3	4	145	149	152
		Yes	78	35	42	50	8	16	23	29	32	35	73	90	107	3	7	11	161	187	214
Hospital admission	C	No	3079	38	39	39	0	0	1	32	32	32	38	40	42	1	1	2	110	113	115
		Yes	91	42	45	47	11	12	14	30	33	35	40	51	63	1	3	4	129	144	159
	I	No	3095	38	39	39	0	1	1	37	38	38	66	69	71	2	3	3	145	148	151
		Yes	90	36	38	41	9	15	21	34	38	41	72	86	101	14	27	40	177	204	232
Event in pregnancy	C	No	2951	39	39	39	0	1	1	31	32	32	38	40	42	1	1	1	110	112	115
		Yes	221	35	36	37	3	4	4	33	34	36	39	46	53	4	10	16	118	130	142
	I	No	2804	39	39	40	0	1	1	38	39	40	69	71	74	2	3	3	150	153	156
		Yes	393	33	34	35	2	4	5	27	28	29	47	53	59	4	7	10	116	126	135
Prelabour rupture	C	No	2965	38	39	39	1	1	1	32	32	32	38	40	42	1	1	2	110	113	115
		Yes	205	39	41	42	2	2	3	31	32	34	37	45	53	2	3	5	113	123	133
	I	No	3069	38	39	39	1	1	1	37	38	38	66	68	71	2	3	3	145	148	151
		Yes	122	42	44	46	2	5	7	39	42	44	74	85	97	9	19	29	175	194	214
Delivery and postpartum																					
Adverse diagnosis at admission to labour	C	No	2919	38	39	39	0	1	1	31	32	32	37	39	41	1	1	1	108	111	113
		Yes	253	38	40	41	2	3	4	35	36	38	49	56	64	5	11	16	135	146	157
	I	No	2931	38	39	39	0	1	1	36	37	37	60	62	65	1	2	2	137	140	143
		Yes	266	39	40	42	4	7	10	47	48	50	128	139	150	13	18	24	238	253	268
Labour	C	Spont	2943	38	38	39	0	1	1	31	31	32	37	39	41	1	1	2	108	111	113
		Induced	118	42	45	47	2	2	3	30	32	34	38	47	57	0	1	2	116	127	138
	I	Elective CS	106	43	46	48	2	4	6	49	51	53	65	76	88	4	8	12	171	185	199
		Spont	3003	38	38	39	0	1	1	36	37	37	63	65	67	2	2	3	140	143	146
		Induced	128	48	50	52	2	5	8	44	47	50	98	113	128	4	9	13	205	224	242
		Elective CS	59	41	44	47	2	9	16	57	59	61	155	176	197	15	33	51	289	321	352
Postpartum anaemia	C	No	3020	38	39	39	1	1	1	31	32	32	38	40	42	1	1	2	111	113	115
		Yes	146	39	41	43	1	1	1	32	34	36	36	50	63	1	3	5	113	128	143
	I	No	3015	39	39	39	1	1	1	37	38	38	66	69	71	2	3	4	146	149	152
		Yes	176	34	35	37	0	0	1	37	39	42	66	77	88	3	5	8	143	157	171

Table 13.2: Differences between cost for women with different risks or event status in Thailand.

VARIABLE	Arm	Detail	N	Outpatient ANC			Inpatient ANC			Delivery care			Postpartum care			Neonatal care			All care		
				Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High
Mode of delivery	C	Spont	2862	38	38	39	1	1	1	30	30	30	32	34	35	1	1	2	102	104	106
		Elective CS	121	42	44	46	2	4	6	51	52	54	71	82	93	4	7	11	176	189	203
		Intra CS	79	33	35	37	0	1	2	48	50	51	95	115	134	2	4	6	183	205	227
		Forceps	40	49	53	57	0	0	1	53	60	66	137	182	226	0	0	1	245	295	346
		Ass breech	25	32	36	40	0	0	1	25	28	31	9	24	39	0	2	4	73	90	106
	I	Spont	2860	37	38	38	1	1	1	35	35	36	54	56	58	2	2	3	129	132	135
		Elective CS	76	46	49	52	0	6	11	58	60	62	156	174	191	6	10	14	277	298	320
		Intra CS	127	43	45	47	2	5	9	62	64	66	194	210	226	14	22	31	327	347	367
		Forceps	52	47	50	53	0	0	0	60	66	72	186	219	251	1	5	8	301	339	377
		Ass breech	22	25	30	34	0	2	4	25	32	39	31	50	69	2	3	5	89	117	146
Birth weight	C	LBW	265	30	31	32	1	1	2	29	30	31	30	38	46	7	12	18	101	112	124
		NBW	2887	39	40	40	1	1	1	32	32	33	39	41	43	0	0	1	111	114	116
	I	LBW	281	32	35	37	1	2	3	38	39	41	73	82	91	20	26	33	170	185	199
		NBW	2888	39	39	40	1	1	1	37	38	38	66	68	70	1	1	1	144	147	150
Gest age at birth	C	Preterm	243	25	26	27	1	2	2	27	28	29	24	32	39	6	12	17	87	99	111
		Normal	2694	39	39	40	1	1	1	32	32	33	40	42	44	1	1	1	112	115	117
		Post-term	232	45	46	48	1	1	2	30	32	33	29	35	40	0	0	1	107	114	122
	I	Preterm	288	29	31	33	1	2	4	33	35	37	55	64	72	15	22	28	141	154	167
		Normal	2702	38	39	39	1	1	1	37	37	38	66	68	71	1	1	2	144	147	150
		Post-term	199	47	49	50	0	1	1	43	46	48	78	88	97	1	1	1	171	183	195
Congen malform	C	No	3127	39	39	39	1	1	1	32	32	32	38	40	42	1	1	2	111	114	116
		Yes	28	29	32	35	0	0	0	31	36	41	32	71	110	0	2	4	96	141	187
	I	No	3155	38	39	39	1	1	1	37	38	38	67	69	72	3	3	4	147	150	153
		Yes	20	33	37	40	0	1	2	36	43	50	41	63	84	4	19	33	132	162	192

Table 13.3: Differences between cost for women with different risks or event status in South Africa.

VARIABLE	Detail	N	Outpatient ANC			Inpatient ANC			Delivery care			Postpartum care			Neonatal care			All care		
			Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High
Overall																				
CONTROL		785	43	44	45	64	70	77	94	95	95	89	94	99	40	44	48	335	347	358.7
Risk																				
Age	<16	8	28	34	41	21	56	90	93	104	114	60	85	110	20	28	35	261	306	351.5
	16-40	764	43	44	45	64	71	77	94	94	95	90	95	100	41	45	49	336	348	360.5
	>40	11	41	48	54	37	72	108	85	92	99	52	67	82	9	15	21	241	294	346.9
Substance abuse	No	281	43	44	45	65	75	86	93	94	96	87	94	101	49	59	68	346	366	387.3
	Yes	501	42	44	45	59	68	76	94	95	96	87	94	100	32	36	40	322	336	350.4
Number of pregnancy	First	735	42	43	44	65	72	79	94	95	95	89	94	99	40	45	49	336	348	360.9
	> First	46	46	50	53	37	54	71	92	96	99	78	91	104	27	36	46	293	327	359.9
Previous stillbirth	No	727	42	43	44	63	69	75	93	94	95	87	91	96	41	45	50	331	343	354.7
	Yes	54	49	53	58	49	91	134	95	99	103	97	134	171	23	30	37	349	408	466
Previous abortion	No	530	44	45	46	60	67	74	94	95	96	88	94	99	41	46	52	333	347	360.3
	Yes	123	39	41	43	60	86	112	92	94	96	71	78	85	31	44	57	305	343	380.4
Last baby <2500g	No	697	43	43	44	60	67	74	93	94	95	88	93	99	41	45	50	330	343	355.8
	Yes	21	48	59	71	177	235	293	112	118	124	155	185	215	32	49	66	559	647	734.8
Previous admission	No	664	42	43	44	60	68	75	91	91	92	81	87	92	39	44	49	320	333	346.2
	Yes	80	45	48	51	82	105	128	121	124	127	155	170	186	36	45	54	456	492	527.8
Previous RT surgery	No	672	44	44	45	67	75	82	94	95	96	90	95	101	41	46	51	342	355	368.4
	Yes	20	39	44	48	32	59	86	85	90	95	70	95	119	29	52	74	271	339	406.6
ANC and pregnancy events																				
First visit (weeks)	<12	5	56	66	77	57	153	249	102	117	131	74	148	223	0	0	0	339	484	629.7
	12 to 15	19	63	69	75	45	92	140	88	94	100	63	88	114	13	23	34	303	367	430.9
	16 to 20	131	53	56	58	78	101	125	92	94	96	100	119	138	40	52	64	384	422	460.6
	>20	587	39	40	41	55	62	68	94	95	96	83	87	92	37	42	47	314	326	337.8
Refer to higher level	No	547	40	41	42	42	49	56	90	91	92	77	83	89	34	39	44	291	304	316.5
	Yes	182	52	54	57	113	130	147	103	105	107	114	125	135	43	51	59	438	465	491.7
Event in pregnancy	No	408	39	40	41	33	39	45	92	93	94	79	84	89	38	44	51	287	300	313.1
	Yes	377	46	48	49	92	104	116	95	96	98	97	106	114	39	44	50	378	398	417.8
Prelabour rupture	No	489	43	44	45	59	67	75	93	95	96	87	93	99	40	45	50	329	343	357.9
	Yes	30	40	44	48	9	19	29	94	99	104	80	96	113	43	58	73	286	316	346

Table 13.3: Differences between cost for women with different risks or event status in South Africa.

VARIABLE	Detail	N	Outpatient ANC			Inpatient ANC			Delivery care			Postpartum care			Neonatal care			All care		
			Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High
Delivery and postpartum																				
Adverse diagnosis at	No	470	42	43	44	31	36	41	91	92	93	81	87	93	40	46	52	292	304	316.8
admission to labour	Yes	315	44	45	46	107	121	136	97	98	100	98	106	114	35	41	47	389	411	433.2
Labour	Spont	610	42	43	44	41	46	51	89	90	91	78	83	89	34	39	43	290	301	312.8
	Induced	44	37	40	43	93	148	202	89	92	96	72	90	108	26	42	59	341	412	482.7
	Elective CS	77	50	53	56	196	230	265	138	139	140	179	191	204	78	100	122	668	714	759.8
Postpartum anaemia	No	547	44	45	46	66	74	82	95	96	97	91	96	101	39	44	48	341	355	368.2
	Yes	83	39	42	44	32	49	66	92	95	98	69	89	108	26	37	48	282	311	340.4
Postpartum syphilis	No	291	45	46	47	56	65	73	95	96	98	88	95	102	43	51	58	335	353	370.8
	Yes	33	46	51	56	44	74	104	91	96	100	116	176	235	59	89	119	400	485	570.1
Mode of delivery	Spont	583	41	41	42	31	37	42	81	81	81	60	65	70	26	30	34	245	255	264.7
	Elective CS	91	50	54	57	160	191	222	141	141	141	175	186	197	65	84	103	614	655	695.9
	Intra CS	84	48	51	54	133	163	193	141	141	141	184	199	213	76	92	108	599	644	690
Gest age at birth	Preterm	123	31	32	34	104	128	153	92	94	97	99	113	127	75	98	120	418	466	513.8
	Normal	594	46	47	48	54	61	68	95	96	97	85	90	95	33	36	39	318	329	340.7

Appendix 14: Cost per pregnancy distributions (log and linear)

Figure 14.1: Cuba control group total cost distribution (cases less than US\$2,000)

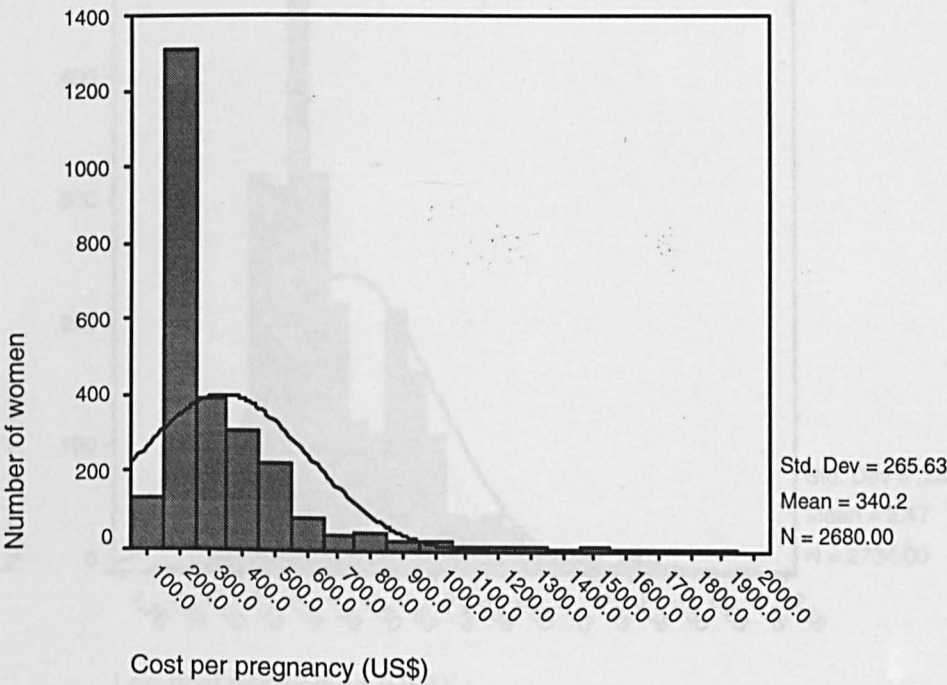


Figure 14.2: Cuba intervention group total cost distribution (cases less than US\$2,000)

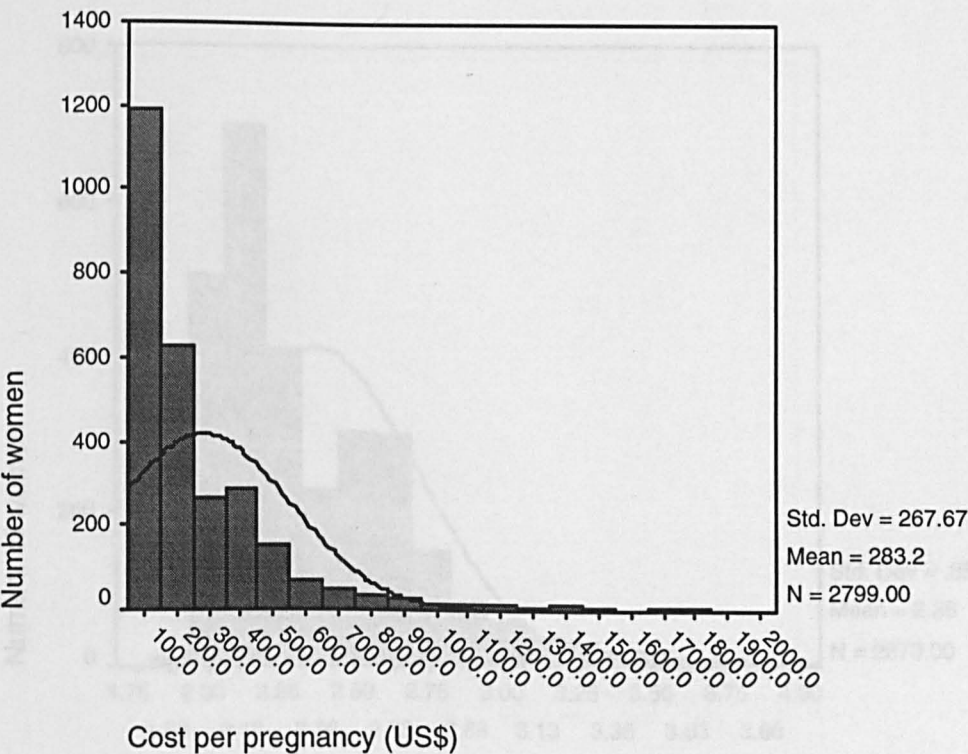


Figure 14.3: Cuba control group log cost distribution (all cases)

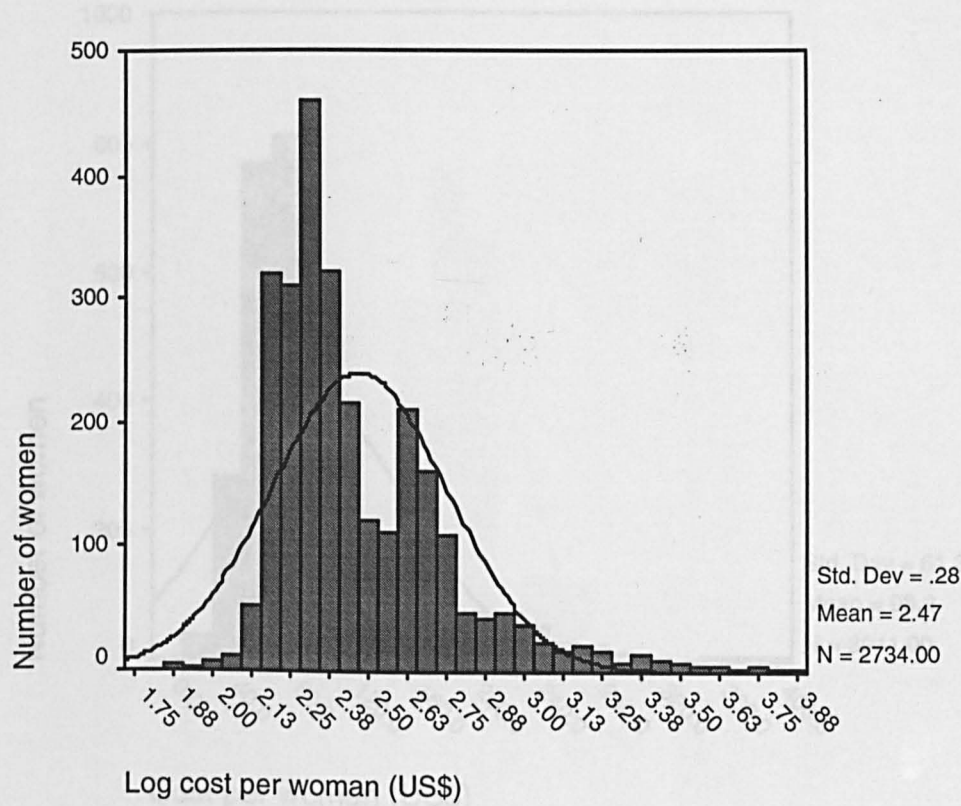


Figure 14.4: Cuba intervention group log cost distribution (all cases)

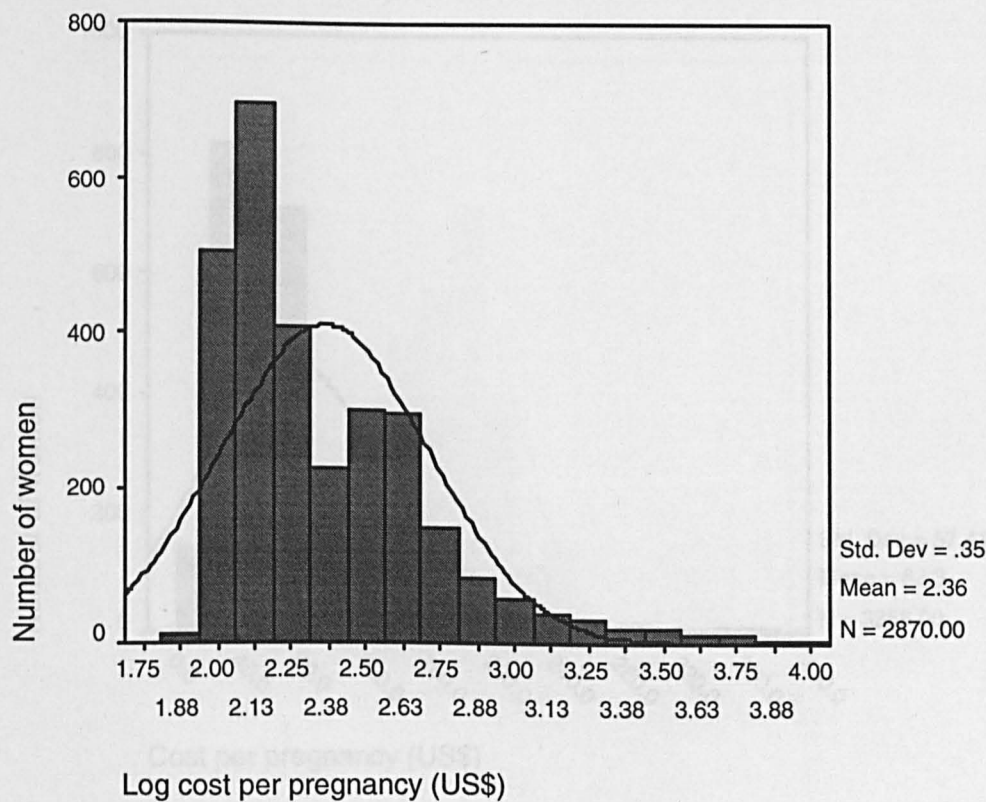


Figure 14.5: Thailand control group total cost distribution (cases less than US\$400)

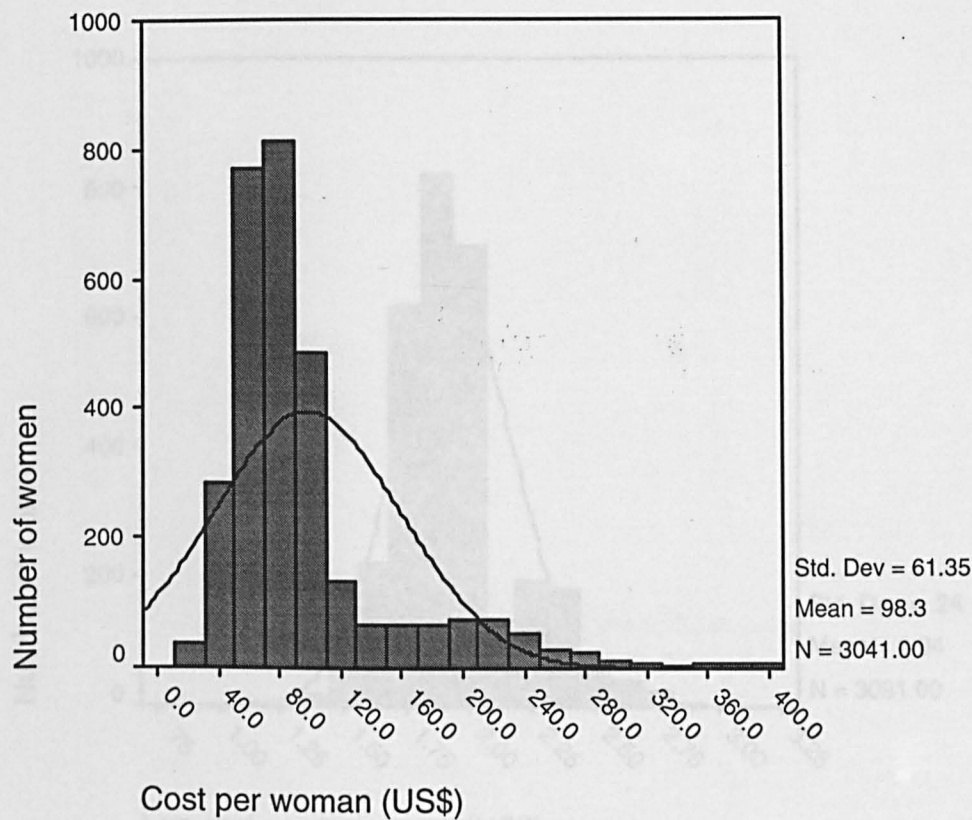


Figure 14.6: Thailand intervention group total cost distribution (cases less than US\$400)

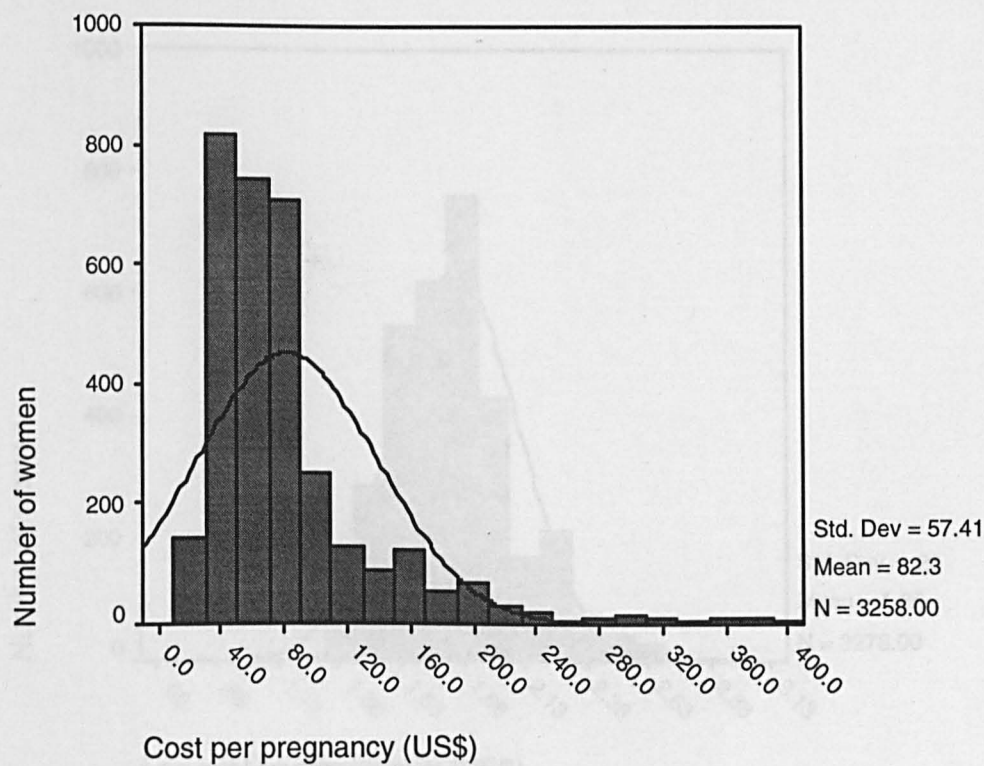


Figure 14.7: Thailand control group log cost distribution (all cases)

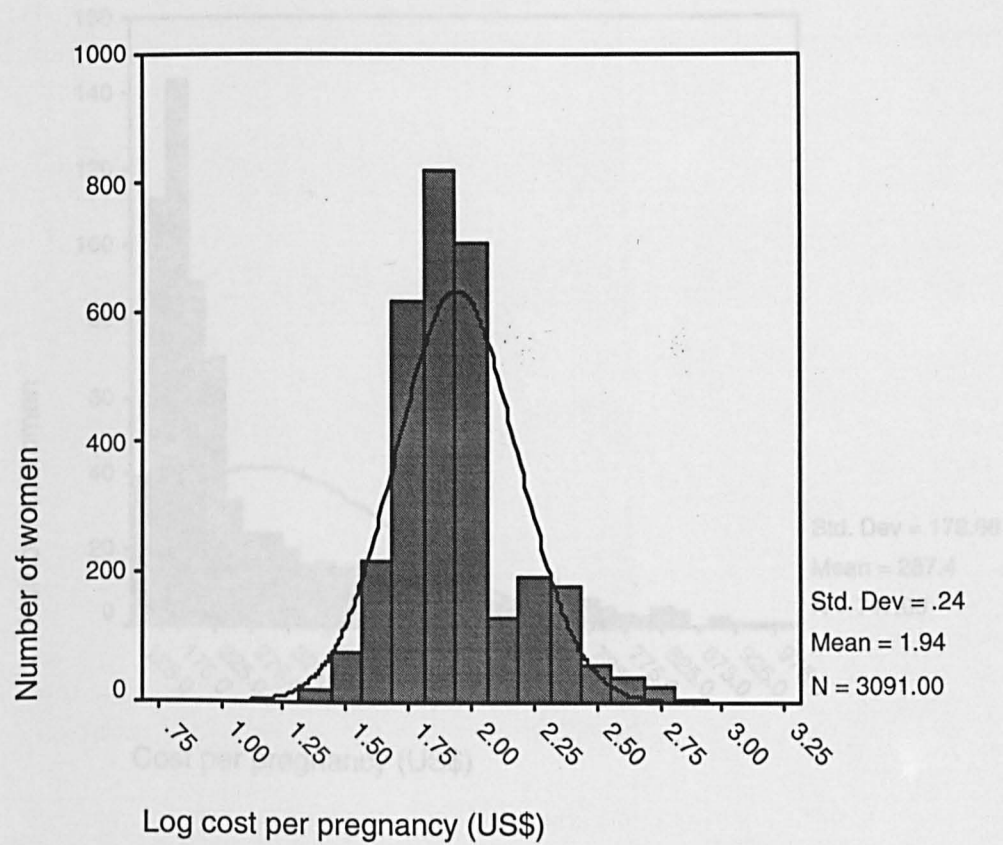


Figure 14.8: Thailand intervention group log cost distribution (all cases)

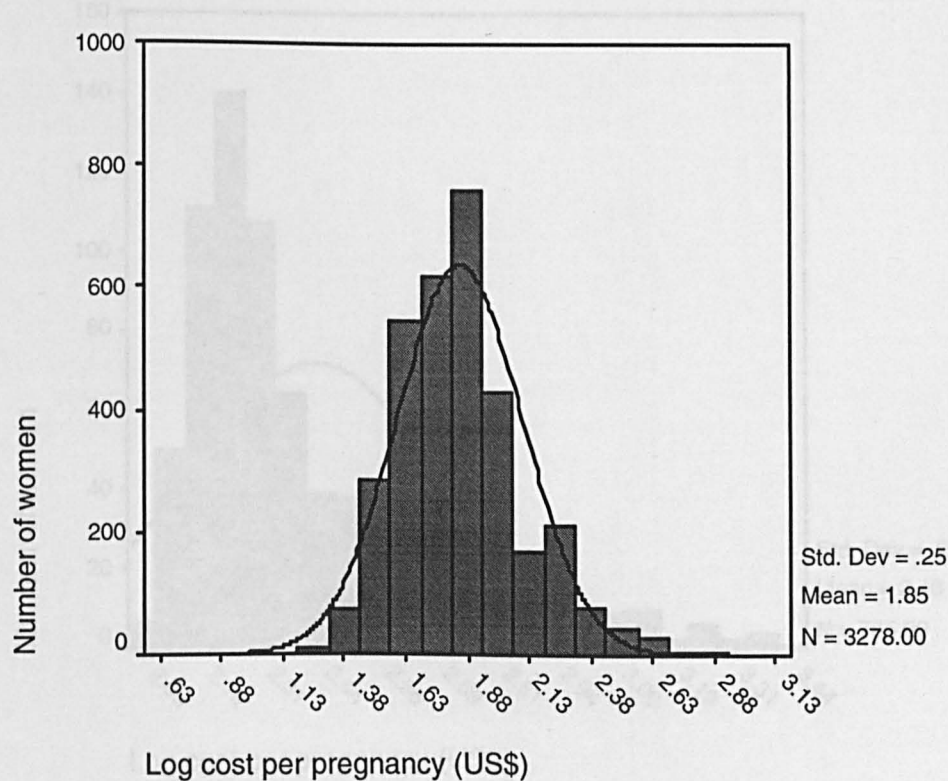


Figure 14.9: South Africa total cost distribution (cases less than US\$1,000)

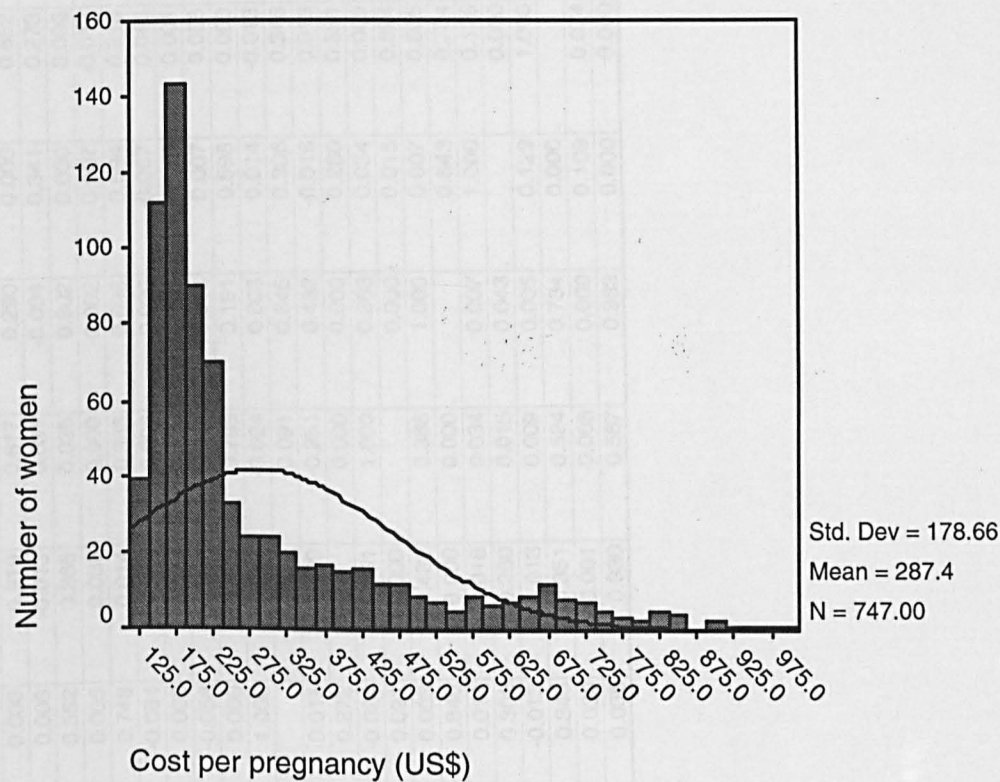


Figure 14.10: South Africa log cost distribution (all cases)

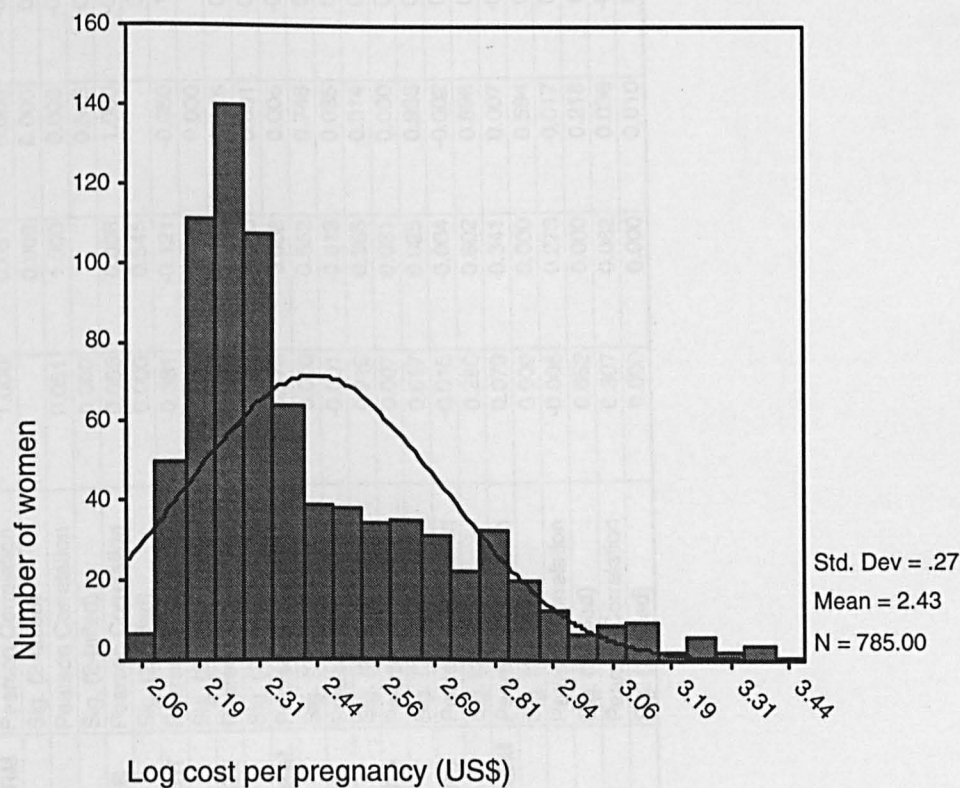


Table 14.1: Correlation coefficients between independent variables for regression analysis in Cuban model

		CPRETERM	CPROM	CADVLAB	CBWEIGHT	CBWEIGT2	CCONGMAL	DFTEOPD	DOCCOPD	DSIZEOPD	EHOSPADMECS	ENNICU	
CPRETERM	Pearson Correlation	1.000	0.051	0.086	-0.381	-0.336	0.076	-0.001	0.007	-0.015	0.079	-0.006	0.307
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000	0.919	0.617	0.290	0.000	0.652	0.000
CPROM	Pearson Correlation	0.051	1.000	0.008	-0.121	-0.106	0.008	-0.013	0.031	-0.004	0.341	0.273	0.082
	Sig. (2-tailed)	0.000		0.545	0.000	0.000	0.552	0.365	0.025	0.802	0.000	0.000	0.000
CADVLAB	Pearson Correlation	0.086	0.008	1.000	-0.050	-0.046	0.005	0.035	0.000	-0.002	0.007	-0.017	0.036
	Sig. (2-tailed)	0.000	0.545		0.000	0.001	0.748	0.014	0.986	0.896	0.594	0.218	0.010
CBWEIGHT	Pearson Correlation	-0.381	-0.121	-0.050	1.000	0.989	-0.084	0.009	0.006	0.020	-0.007	0.046	-0.269
	Sig. (2-tailed)	0.000	0.000	0.000		0.000	0.000	0.530	0.686	0.146	0.630	0.001	0.000
CBWEIGT2	Pearson Correlation	-0.336	-0.106	-0.046	0.989	1.000	-0.058	0.006	0.004	0.018	0.007	0.056	-0.222
	Sig. (2-tailed)	0.000	0.000	0.001	0.000		0.000	0.647	0.785	0.191	0.598	0.000	0.000
CCONGMAL	Pearson Correlation	0.076	0.008	0.005	-0.084	-0.058	1.000	-0.015	-0.024	0.003	0.014	-0.013	0.030
	Sig. (2-tailed)	0.000	0.552	0.748	0.000	0.000		0.272	0.091	0.845	0.306	0.346	0.035
DFTEOPD	Pearson Correlation	-0.001	-0.013	0.035	0.009	0.006	-0.015	1.000	-0.251	0.432	-0.016	0.013	0.001
	Sig. (2-tailed)	0.919	0.365	0.014	0.530	0.647	0.272		0.000	0.000	0.260	0.351	0.930
DOCCOPD	Pearson Correlation	0.007	0.031	0.000	0.006	0.004	-0.024	-0.251	1.000	0.366	0.034	0.009	-0.008
	Sig. (2-tailed)	0.617	0.025	0.986	0.686	0.785	0.091	0.000		0.000	0.015	0.524	0.567
DSIZEOPD	Pearson Correlation	-0.015	-0.004	-0.002	0.020	0.018	0.003	0.432	0.366	1.000	0.007	0.005	0.000
	Sig. (2-tailed)	0.290	0.802	0.896	0.146	0.191	0.845	0.000	0.000		0.643	0.734	0.983
EHOSPADM	Pearson Correlation	0.079	0.341	0.007	-0.007	0.007	0.014	-0.016	0.034	0.007	1.000	0.129	0.109
	Sig. (2-tailed)	0.000	0.000	0.594	0.630	0.598	0.306	0.260	0.015	0.643		0.000	0.000
ECS	Pearson Correlation	-0.006	0.273	-0.017	0.046	0.056	-0.013	0.013	0.009	0.005	0.129	1.000	0.074
	Sig. (2-tailed)	0.652	0.000	0.218	0.001	0.000	0.346	0.351	0.524	0.734	0.000		0.000
ENNICU	Pearson Correlation	0.307	0.082	0.036	-0.269	-0.222	0.030	0.001	-0.008	0.000	0.109	0.074	1.000
	Sig. (2-tailed)	0.000	0.000	0.010	0.000	0.000	0.035	0.930	0.567	0.983	0.000	0.000	

Table 14.2: Correlation coefficients between independent variables for regression analysis in Thai model

		BSCHOOL	BPRABORT	BPRSURG	CADVLAB	CINDUCE	CPPS	DCLINIC	DFTEIPD	EHOSPADM	ECS	ENNICU
BSCHOOL	Pearson Correlation	1.0000	-0.0061	-0.0197	-0.0155	0.0338	-0.0115	-0.0061	0.0251	0.0169	0.0366	0.0262
	Sig. (2-tailed)		0.6398	0.1284	0.2325	0.0090	0.3738	0.6378	0.0529	0.1924	0.0047	0.0431
BPRABORT	Pearson Correlation	-0.0061	1.0000	0.0096	0.0183	0.0081	0.0127	0.0021	-0.0275	0.0311	0.0144	0.0051
	Sig. (2-tailed)	0.6398		0.4598	0.1586	0.5310	0.3250	0.8742	0.0337	0.0164	0.2676	0.6909
BPRSURG	Pearson Correlation	-0.0197	0.0096	1.0000	0.0211	-0.0111	0.0219	-0.0011	-0.0005	0.0038	0.1984	0.0428
	Sig. (2-tailed)	0.1284	0.4598		0.1037	0.3918	0.0913	0.9317	0.9691	0.7691	0.0000	0.0009
CADVLAB	Pearson Correlation	-0.0155	0.0183	0.0211	1.0000	0.1040	0.0233	0.0183	0.0183	0.0759	0.3106	0.1687
	Sig. (2-tailed)	0.2325	0.1586	0.1037		0.0000	0.0724	0.1566	0.1574	0.0000	0.0000	0.0000
CINDUCE	Pearson Correlation	0.0338	0.0081	-0.0111	0.1040	1.0000	0.0023	0.0163	0.0559	0.0090	0.1041	0.0437
	Sig. (2-tailed)	0.0090	0.5310	0.3918	0.0000		0.8594	0.2071	0.0000	0.4858	0.0000	0.0007
CPPS	Pearson Correlation	-0.0115	0.0127	0.0219	0.0233	0.0023	1.0000	0.0036	0.0163	-0.0103	0.0186	0.0026
	Sig. (2-tailed)	0.3738	0.3250	0.0913	0.0724	0.8594		0.7803	0.2091	0.4281	0.1505	0.8416
DCLINIC	Pearson Correlation	-0.0061	0.0021	-0.0011	0.0183	0.0163	0.0036	1.0000	-0.1038	0.0267	0.0002	0.0058
	Sig. (2-tailed)	0.6378	0.8742	0.9317	0.1566	0.2071	0.7803		0.0000	0.0390	0.9857	0.6532
DFTEIPD	Pearson Correlation	0.0251	-0.0275	-0.0005	0.0183	0.0559	0.0163	-0.1038	1.0000	0.0138	0.0120	0.0549
	Sig. (2-tailed)	0.0529	0.0337	0.9691	0.1574	0.0000	0.2091	0.0000		0.2880	0.3537	0.0000
EHOSPADM	Pearson Correlation	0.0169	0.0311	0.0038	0.0759	0.0090	-0.0103	0.0267	0.0138	1.0000	0.0495	0.0745
	Sig. (2-tailed)	0.1924	0.0164	0.7691	0.0000	0.4858	0.4281	0.0390	0.2880		0.0001	0.0000
ECS	Pearson Correlation	0.0366	0.0144	0.1984	0.3106	0.1041	0.0186	0.0002	0.0120	0.0495	1.0000	0.1173
	Sig. (2-tailed)	0.0047	0.2676	0.0000	0.0000	0.0000	0.1505	0.9857	0.3537	0.0001		0.0000
ENNICU	Pearson Correlation	0.0262	0.0051	0.0428	0.1687	0.0437	0.0026	0.0058	0.0549	0.0745	0.1173	1.0000
	Sig. (2-tailed)	0.0431	0.6909	0.0009	0.0000	0.0007	0.8416	0.6532	0.0000	0.0000	0.0000	

Table 14.2: Correlation coefficients between independent variables for regression analysis in South African model

		BPRLBW	BPRADM	BGESTVIS	BREFER	CPRETERM	CPROM	CADVLAB	CPRESENT	CPPS	CCONGMAL	EHOSPADM	ECS	ENNICU
BPRLBW	Pearson Correlation	1.0000	0.0154	0.0244	-0.0126	-0.0412	-0.0243	0.0546	-0.0142	-0.0554	-0.0414	0.0190	-0.0120	0.0799
	Sig. (2-tailed)		0.6664	0.4948	0.7245	0.2490	0.4965	0.1261	0.6916	0.1211	0.2605	0.5954	0.7380	0.0319
BPRADM	Pearson Correlation	0.0154	1.0000	0.0054	0.1895	0.0154	-0.0428	0.1059	0.0403	0.0046	0.0724	0.0644	0.1578	0.0355
	Sig. (2-tailed)	0.6664		0.8800	0.0000	0.6664	0.2312	0.0030	0.2594	0.8974	0.0486	0.0711	0.0000	0.3409
BGESTVIS	Pearson Correlation	0.0244	0.0054	1.0000	0.0410	0.0163	-0.0320	-0.0152	0.0308	-0.0391	-0.0095	-0.0006	0.0010	0.0015
	Sig. (2-tailed)	0.4948	0.8800		0.2507	0.6477	0.3703	0.6697	0.3887	0.2736	0.7963	0.9862	0.9780	0.9687
BREFER	Pearson Correlation	-0.0126	0.1895	0.0410	1.0000	-0.0126	0.0704	0.0860	0.0513	-0.0700	0.0451	0.1683	0.2279	0.0504
	Sig. (2-tailed)	0.7245	0.0000	0.2507		0.7245	0.0487	0.0159	0.1514	0.0501	0.2198	0.0000	0.0000	0.1768
CPRETERM	Pearson Correlation	-0.0412	0.0154	0.0163	-0.0126	1.0000	0.2220	0.0332	0.0074	0.0843	0.0383	0.0288	-0.0035	0.0634
	Sig. (2-tailed)	0.2490	0.6664	0.6477	0.7245		0.0000	0.3529	0.8350	0.0181	0.2979	0.4197	0.9211	0.0889
CPROM	Pearson Correlation	-0.0243	-0.0428	-0.0320	0.0704	0.2220	1.0000	0.0466	-0.0131	0.0247	0.0319	0.0830	0.0136	0.0648
	Sig. (2-tailed)	0.4965	0.2312	0.3703	0.0487	0.0000		0.1922	0.7137	0.4901	0.3862	0.0200	0.7032	0.0819
CADVLAB	Pearson Correlation	0.0546	0.1059	-0.0152	0.0860	0.0332	0.0466	1.0000	0.1108	-0.1067	0.0616	0.1793	0.1172	0.3108
	Sig. (2-tailed)	0.1261	0.0030	0.6697	0.0159	0.3529	0.1922		0.0019	0.0027	0.0934	0.0000	0.0010	0.0000
CPRESENT	Pearson Correlation	-0.0142	0.0403	0.0308	0.0513	0.0074	-0.0131	0.1108	1.0000	0.0019	-0.0041	0.0573	0.3033	0.1251
	Sig. (2-tailed)	0.6916	0.2594	0.3887	0.1514	0.8350	0.7137	0.0019		0.9566	0.9112	0.1090	0.0000	0.0008
CPPS	Pearson Correlation	-0.0554	0.0046	-0.0391	-0.0700	0.0843	0.0247	-0.1067	0.0019	1.0000	-0.0211	0.0062	0.0098	-0.0350
	Sig. (2-tailed)	0.1211	0.8974	0.2736	0.0501	0.0181	0.4901	0.0027	0.9566		0.5669	0.8628	0.7837	0.3482
CCONGMAL	Pearson Correlation	-0.0414	0.0724	-0.0095	0.0451	0.0383	0.0319	0.0616	-0.0041	-0.0211	1.0000	-0.0078	0.0451	0.0125
	Sig. (2-tailed)	0.2605	0.0486	0.7963	0.2198	0.2979	0.3862	0.0934	0.9112	0.5669		0.8314	0.2198	0.7414
EHOSPADM	Pearson Correlation	0.0190	0.0644	-0.0006	0.1683	0.0288	0.0830	0.1793	0.0573	0.0062	-0.0078	1.0000	0.1465	0.0433
	Sig. (2-tailed)	0.5954	0.0711	0.9862	0.0000	0.4197	0.0200	0.0000	0.1090	0.8628	0.8314		0.0000	0.2460
ECS	Pearson Correlation	-0.0120	0.1578	0.0010	0.2279	-0.0035	0.0136	0.1172	0.3033	0.0098	0.0451	0.1465	1.0000	0.3452
	Sig. (2-tailed)	0.7380	0.0000	0.9780	0.0000	0.9211	0.7032	0.0010	0.0000	0.7837	0.2198	0.0000		0.0000
ENNICU	Pearson Correlation	0.0799	0.0355	0.0015	0.0504	0.0634	0.0648	0.3108	0.1251	-0.0350	0.0125	0.0433	0.3452	1.0000
	Sig. (2-tailed)	0.0319	0.3409	0.9687	0.1768	0.0889	0.0819	0.0000	0.0008	0.3482	0.7414	0.2460	0.0000	

Figure 15.1: Normal P-P plot of regression standardized residuals in Cuba
Appendix 15: Diagnostic tests for multiple regression analysis

Table 15.1: Distribution of log cost in Cuba

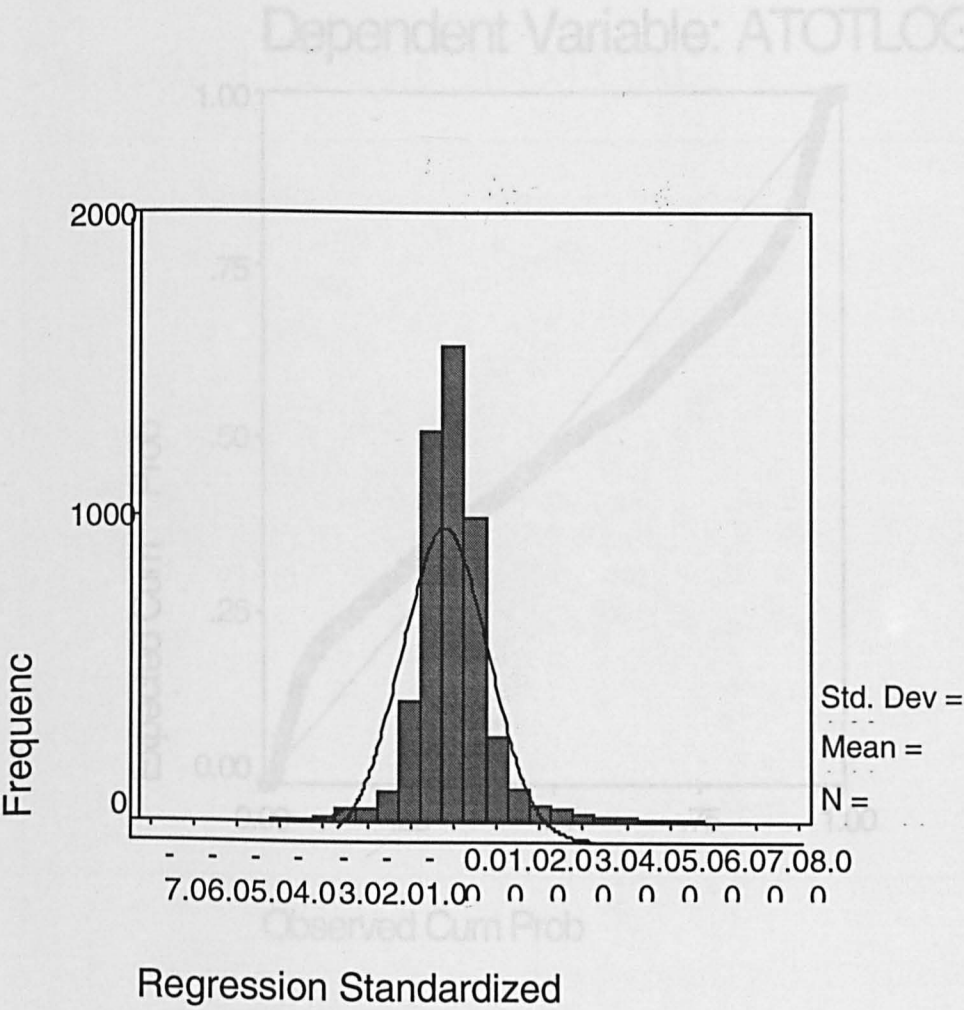


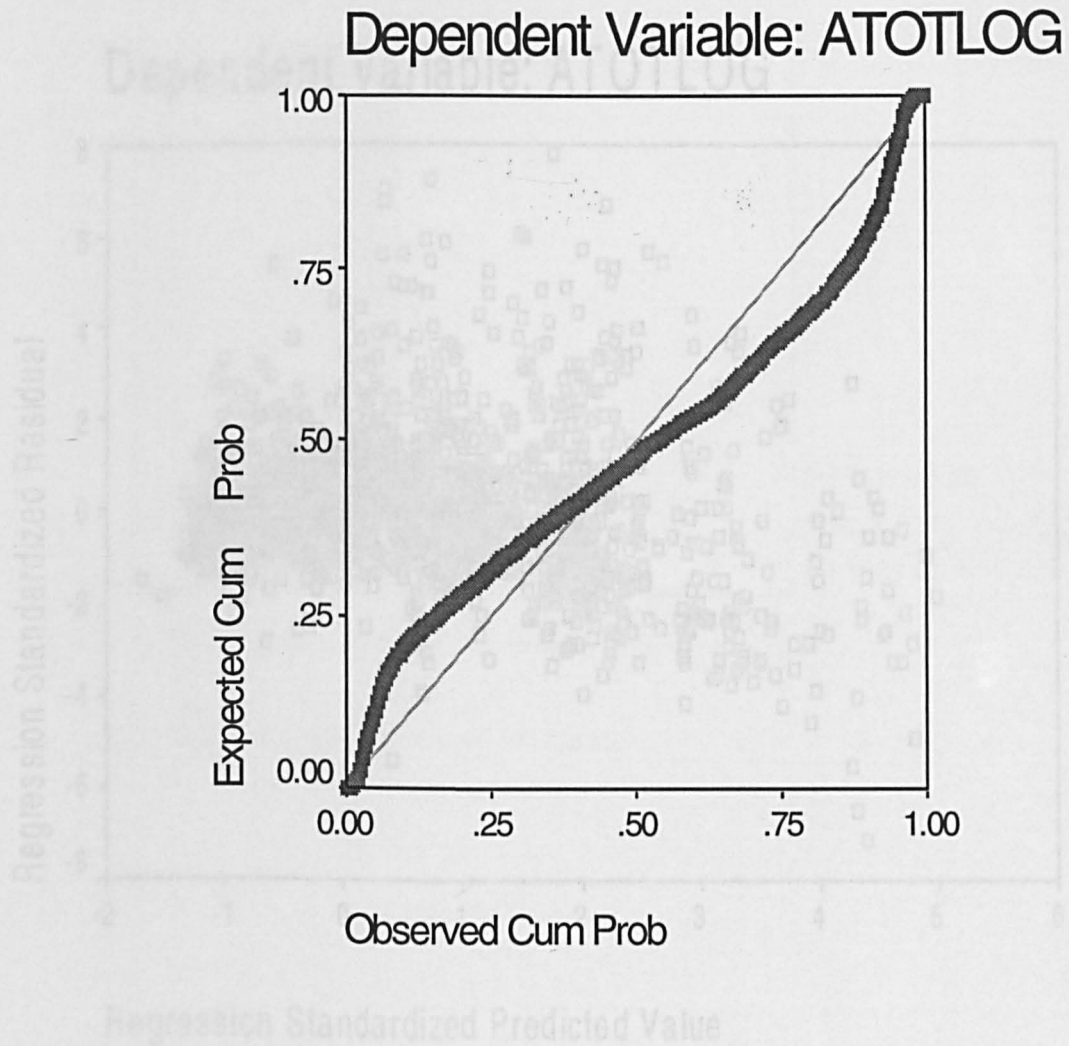
Figure 15.2: Normal P-P plot of regression standardized residuals in Cuba

Figure 15.3: Scatter plot of regression standardized residuals and regression standardized predicted values in Cuba

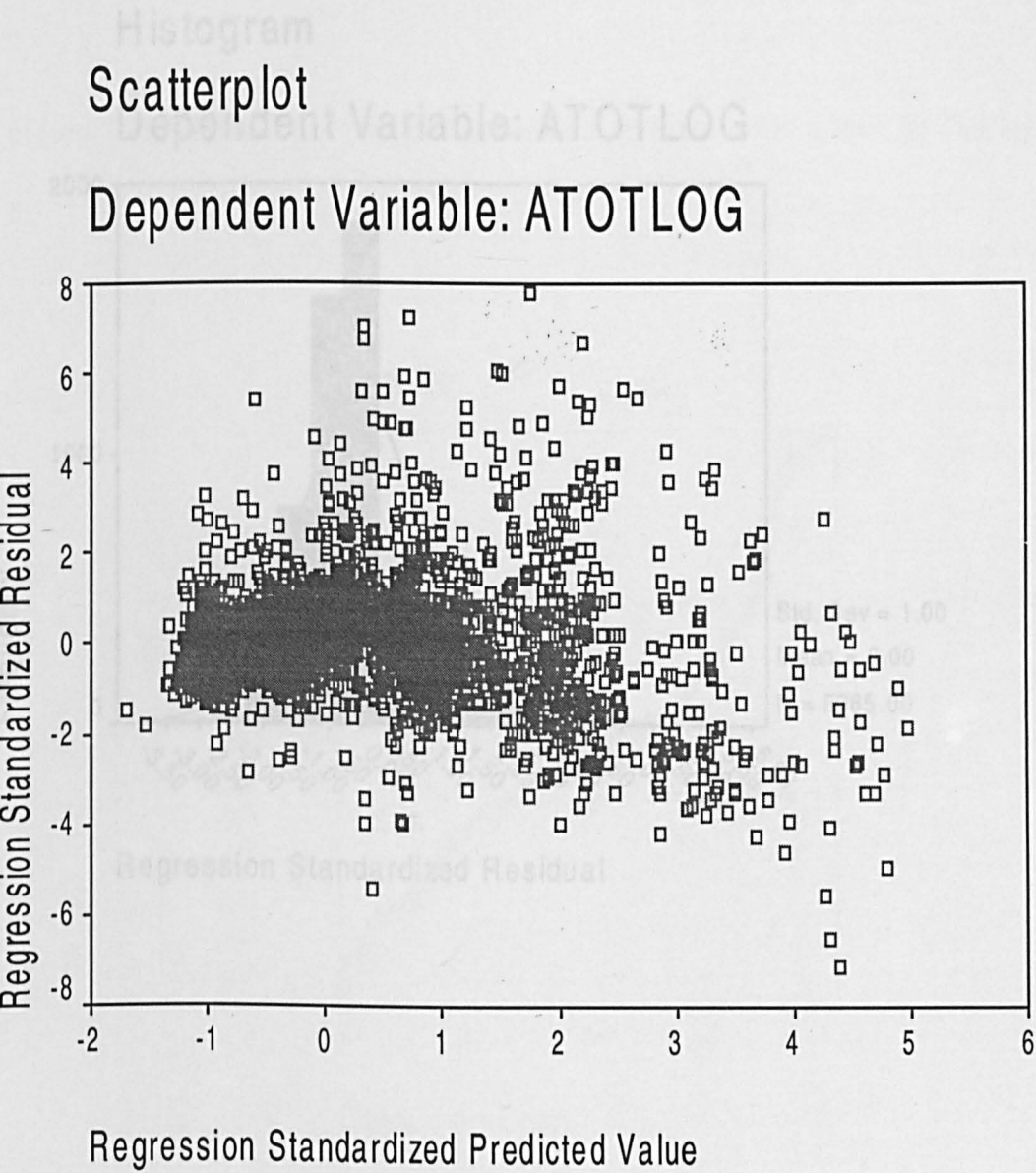


Table 15.4: Distribution of log cost in Thailand

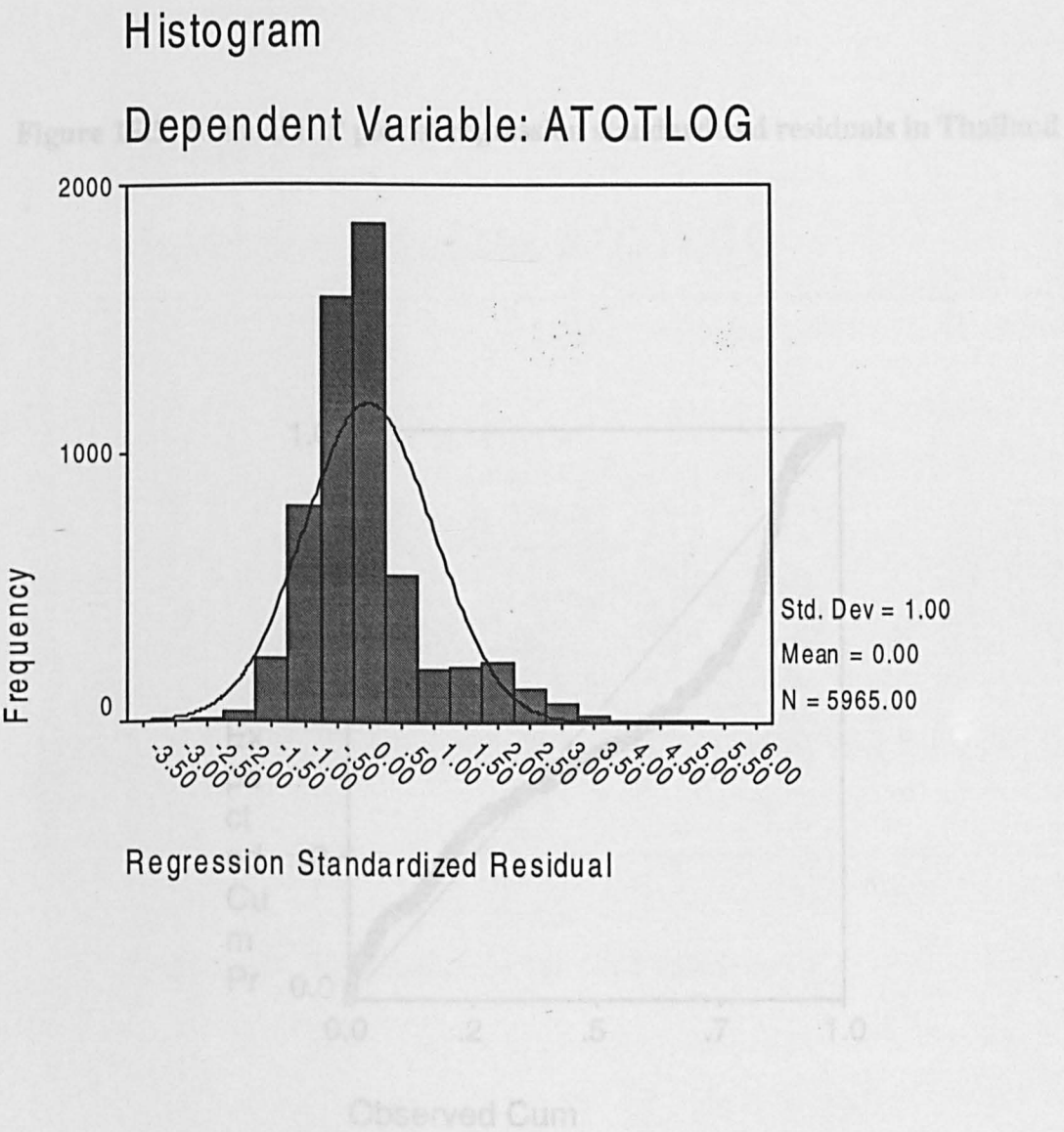


Figure 13.4: Scatter plot of regression standardized residuals and regression standardized predicted values in Thailand

Figure 15.5: Normal P-P plot of regression standardized residuals in Thailand

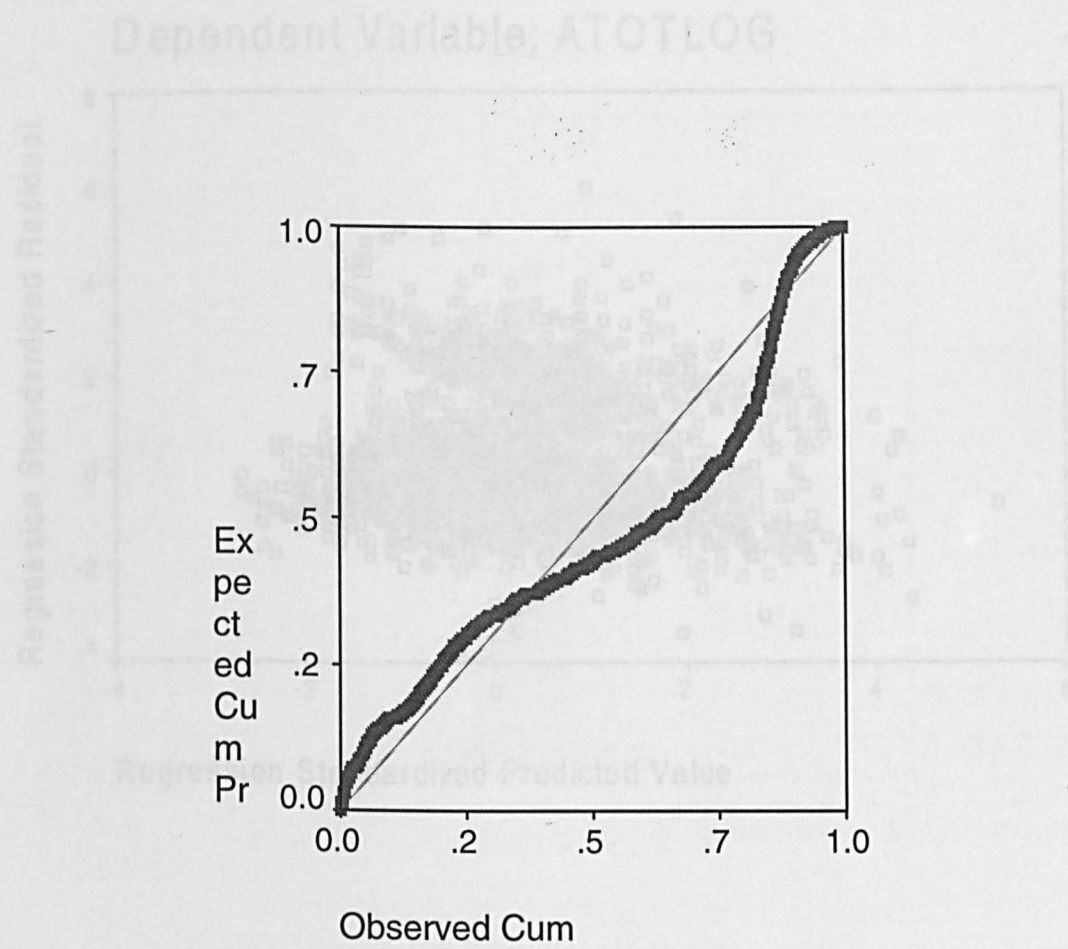


Figure 15.6: Scatter plot of regression standardized residuals and regression standardized predicted values in Thailand

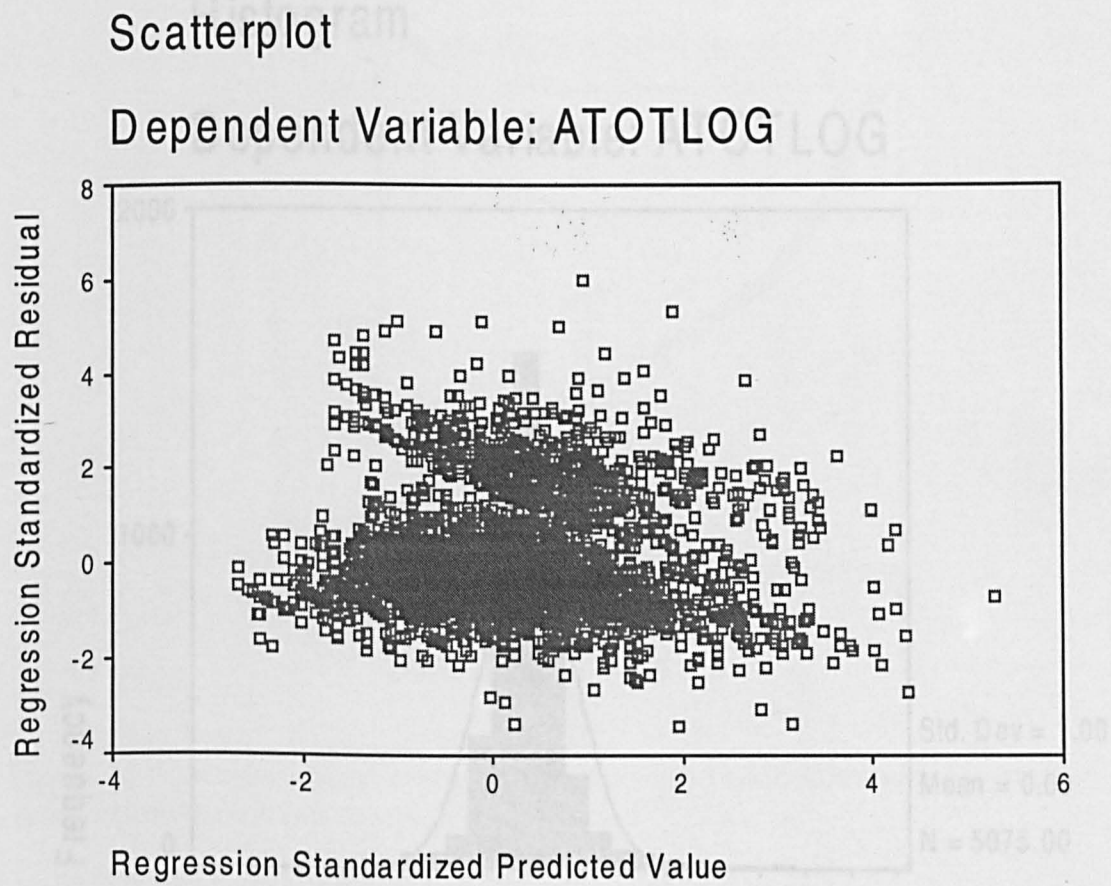


Figure 15.8: Normal P-P plot of regression standardized residuals in South Africa

Table 15.7: Distribution of log cost in South Africa

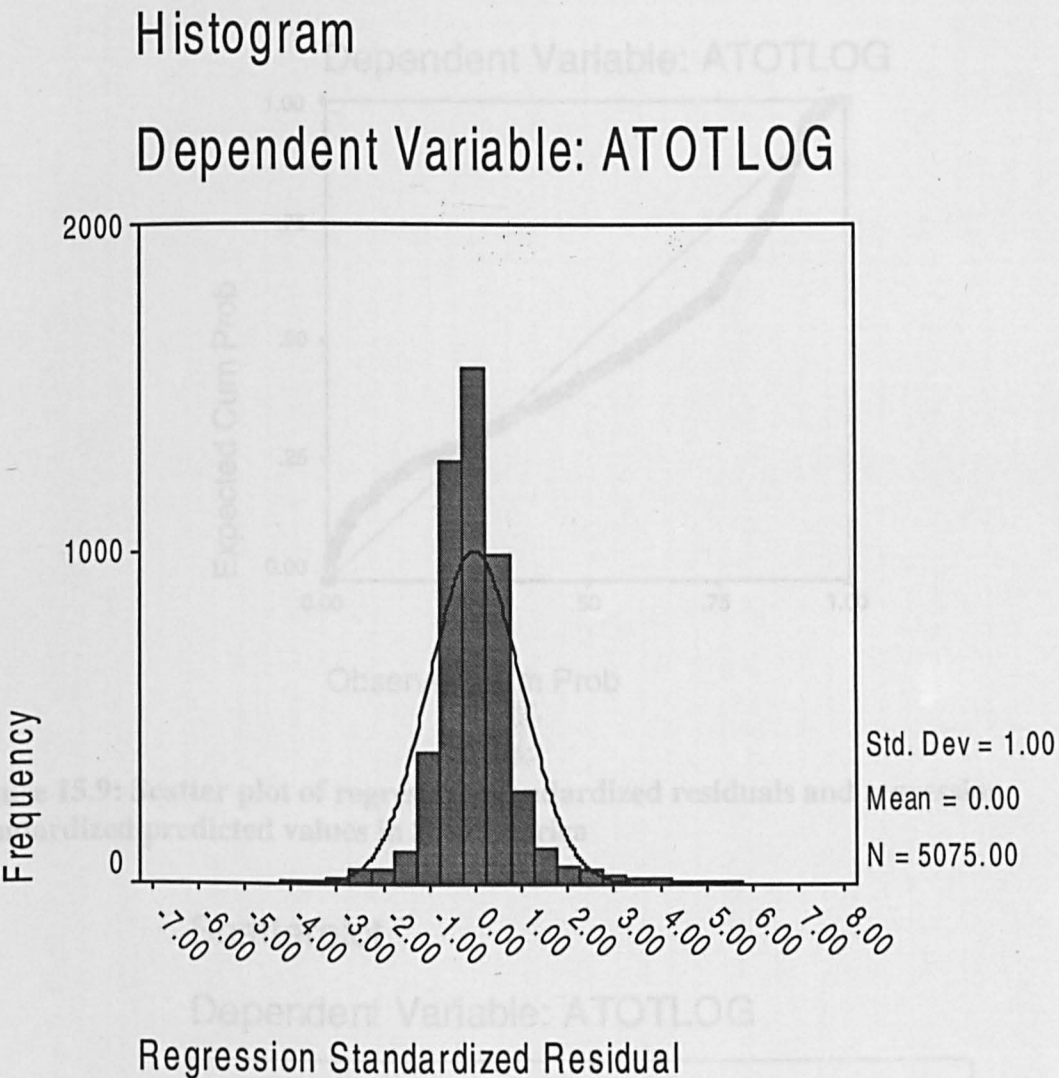


Figure 15.8: Normal P-P plot of regression standardized residuals in South Africa

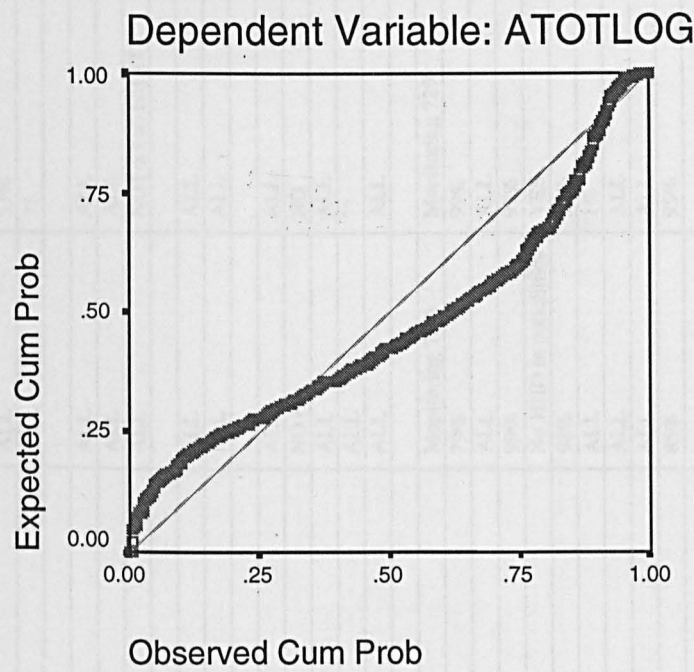
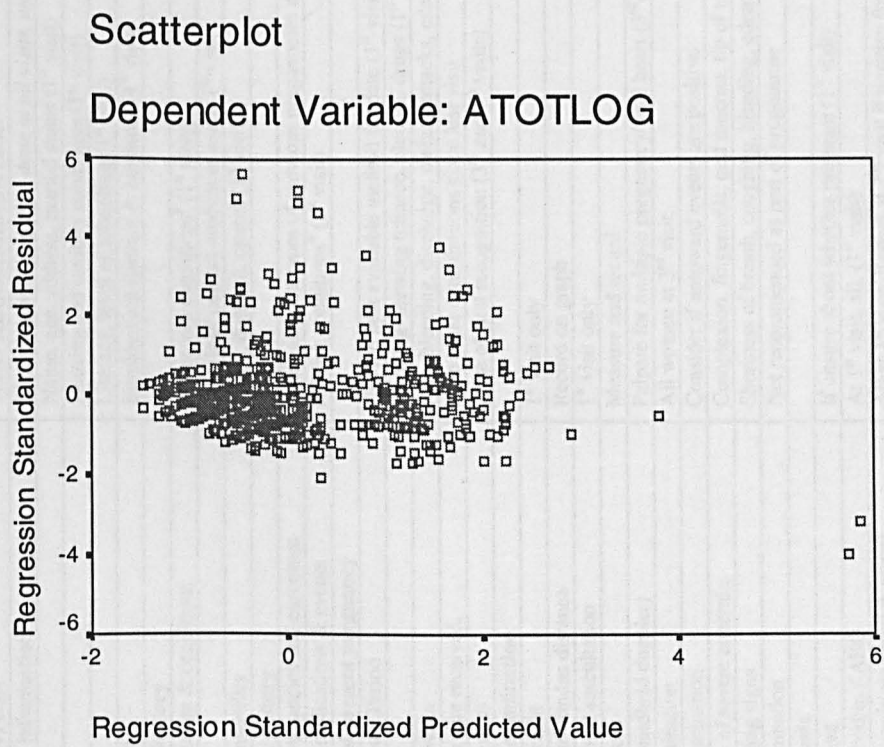


Figure 15.9: Scatter plot of regression standardized residuals and regression standardized predicted values in South Africa



Appendix 16: Cost prediction methods and results

Table 16.1: Comparison of antenatal care interventions in Cuba, Thailand, and South Africa, compared with the new model

INTERVENTION	WHO RECOMMENDATION	CUBA	THAILAND	SOUTH AFRICA
1. Personal information¹	<i>(these interventions were done at all visits, unless indicated otherwise)</i>			
Personal	Name, age, address, marital status (1 st visit)	ALL	ALL	ALL
Social	Housing and sanitary conditions (1 st visit)	ALL	NOT SYSTEMATIC	NOT SYSTEMATIC
Educational	Literacy, level of schooling (1 st visit)	ALL	53%	NO
Current work	Employment (patient & husband) (1 st visit)	ALL	??	NO
2. Medical history				
Specific diseases & conditions	All known conditions ² (1 st visit)	ALL	ALL	ALL (not HIV status)
Medication	Details of current medicines used (1 st visit)	ALL	ALL	ALL
Periods of infertility	When, duration, causes (1 st visit)	ALL	NOT SYSTEMATIC	NO (older women asked)
3. Obstetric history				
Previous pregnancies and outcomes	Dates and outcomes of previous pregnancies and births ³ (1 st visit)	ALL	ALL	ALL
Maternal complications & events	All risk conditions ⁴ (1 st visit)	ALL	ALL	ALL
4. History of present pregnancy				
Last Menstrual Period	Use the best available method for date (1 st visit)	ALL	ALL	ALL
Habits	Smoking/chewing tobacco, alcohol, drugs (1 st visit)	NO (?)	NO	NOT SYSTEMATIC
Untoward events	Pain, bleeding, discharge, malaria attacks, edema	ALL	ALL	ALL
Other health care received.	Note other consultations since last visit	ALL	??	NO
Fetal movements	Time of first recognition (3 rd and 4 th visits)	ALL	ALL	ALL
5. Physical examination				
Weight & height	1 st visit only	Monitoring 76%	Monitoring 72%	Monitoring 71%
Symphysis-to-fundus distance	Record on graph	79%	99%	1.2%
Heart and chest auscultation	1 st visit only	ALL	ALL	ALL
Blood pressure	Measure and record	99%	97%	98%
Palpation (handheld doppler)	Palpate for multiple pregnancy/fetal heart (3 rd & 4 th visits)	No HHD in policlinics	YES	?
Breast examination	All women at 3 rd visit.	98%	99%	49%
Vaginal examination	Consider if untoward events are positive	ALL	1%	2%
Check signs of severe anaemia	Complexion, fingernails, oral mucosa, tip of tongue	ALL	ALL	ALL
Other alarming signs	Shortness of breath, coughing, bleeding, edema	ALL	ALL	ALL
Dental examination	Not recommended as part of programme	85%	95%	NO
6. Special tests				
Pregnancy test	If unsure about whether pregnant (1 st visit)	When required	When required	When required (hospital)
Rhesus antibodies / ABO	At 1 st visit, all. (1 st visit)	93%	27%	29%
Bacteriuria (multiple dipstick urine)	All at 1 st visit. Repeat at 2 nd visit if positive from 1 st .	6%	NO	98%
Protein (multiple dipstick urine)	All at 1 st visit. HR retest at 2 nd . NP/ HR MP at 3 rd & 4 th .	ALL	ALL	NO
Haemoglobin	1 st visit if signs of severe anaemia. 2 nd , if first test <70g/l. 3 rd Hb to all.	ALL	ALL	56%
Pap smear	ALL	44%	NO	NO
Alpha-fetoprotein	HR	69%	NO	NO

INTERVENTION	WHO RECOMMENDATION	CUBA	THAILAND	SOUTH AFRICA
Syphilis test	At 1 st visit, RPR on spot	98% (delayed result)	98% (delayed result)	54% (delayed results)
Hepatitis B	HR	48%	24%	NO
HIV antibody	HR	93%	49%	NO
Malaria screening	HR	HR	HR	NO
Toxoplasmosis	HR	1%	NO	NO
Trichomoniasis / yeast	HR	88%	NO	2%
Gonococcal investigation	HR	NO	NO	NO
Ultrasound scanning	HR	57%	3%	26%
Oral glucose test	Do not perform	12%	NO	2%
Fasting blood glucose test	Do not perform	96%	NO	9%
Haematocrit	Do not perform	96%	97%	1%
7. Risk assessment and referral				
Risk assessment	Formal risk score assessment of high risk conditions ⁵ at 1 st visit; update on later visits	88%	NO	75% (not 'formal')
Referral for untoward symptoms	If protein, bacteriuria after treating, bleeding, pre-eclampsia, IUGR, no fetal movement.	ALL	ALL	ALL
Hospital delivery mandatory	At 4 th visit, if twins or breech suspected; Hb continuously <70g/l, >130g/l.	ALL	ALL	ALL
8. Intervention				
Iron	60mg elemental iron & 250 micrograms folate - once a day for all women (twice if severe); check compliance. At 2 nd and 3 rd visits, increase dose if <70g/l.	83%	95%	91%
Syphilis	Treat those who are RPR positive, with partner referral	YES	YES	YES
Tetanus toxoid	First injection at 1 st visit. Second at 3 rd visit	34%	92%	97%
Malaria	Malaria endemic area - chloroquin, if not resistant	No malaria	HR	No malaria
9. Advice and education				
Advice on reproductive health	One-to-one advice on safe sex, contraception, breastfeeding and lactation (all visits), and postpartum visit (4 th visit)	ALL	NO (group session)	NO (group session)
Advice on habits	One-to-one advice on smoking, alcohol, drugs	ALL	NO (group session)	NO (group session)
Advice on danger signs	Give the woman emergency numbers. Advise woman what to do when bleeding, and at 3 rd and 4 th visits, action in case of labour. Advise on transport for delivery.	ALL	ALL (but no emergency number)	ALL (but no emergency number)
Questions and answers	Session on one-to-one basis	ALL	NO (group session)	NO (group session)
Next appointment	Arrange date of next visit.	ALL	ALL	ALL
10. Record keeping				
Office record	Update record	ALL	ALL	NO
Home based record	Update record	NO	NO	ALL

KEY: HR - High risk women only; ALL - All women; NP - Nulliparous women; MP - Multiparous women; YES - Means a service is available for those who need it.

¹ For repeat visits, check that there are no changes since the previous visit.

² TB, heart disease, chronic renal disease, epilepsy, diabetes mellitus, VD, HIV, hepatitis, malaria, sickle cell trait, Rh status, allergies, blood transfusions.

³ Twins, LBW, HBW, IUGR, death, malformation, Rh-antibody affection, resuscitation.

⁴ Recurrent early abortion, induced abortion complications, thrombosis, embolus, hypertension/pre-eclampsia/eclampsia, placental abruption, placenta previa, breech, obstructed labour, CS/forceps/vacuum, manual removal of placenta, tears, excessive bleeding, puerperal sepsis, gestational diabetes.

⁵ Diabetes (R), heart disease (R), renal disease(R), epilepsy (T), drug abuse (T), signs of severe anaemia (R, T), HIV positive (R), risk of genetic disease (R), primigravida (H), previous stillbirth (R), previous growth-retarded fetus (R), hospital admission for pre-eclampsia/eclampsia (R), previous CS (H), high BP (R), body mass index (R-nutritional evaluation). Key: R=Refer. H=Hospital delivery. T=Treat.

Table 16.2: Rates of adverse events or conditions in control arms in study countries.

Adverse event or condition	Cuba		Thailand		South Africa	
	No.	%	No.	%	No.	%
Number of women	2559	100%	3172	100%	785	100%
Pregnancy events						
HDP, with treatment	92	3.60%	0	0.00%	42	5.35%
HDP, no treatment	71	2.77%	9	0.28%	53	6.75%
Eclampsia	0	0.00%	4	0.13%	3	0.38%
Pre-eclampsia	44	1.72%	19	0.60%	27	3.44%
Severe UTI	252	9.85%	41	1.29%	125	15.92%
UTI, with antibiotic treatment	219	8.56%	50	1.58%	119	15.16%
UTI, no treatment	48	1.88%	18	0.57%	18	2.29%
Vaginal bleeding during pregnancy	83	3.24%	34	1.07%	15	1.91%
Severe pregnancy anemia	153	5.98%	56	1.77%	N/a	N/a
Syphilis, treated	41	1.60%	3	0.09%	80	10.19%
Syphilis, untreated	20	0.78%	9	0.28%	N/a	N/a
Trichomoniasis, treated	1010	39.47%	50	1.58%	130	16.56%
Other STD, treated	254	9.93%	18	0.57%	63	8.03%
WOMEN WITH ANY EVENT	1847	72.18%	238	7.50%	377	48.03%
Labour and delivery events						
Prelabour rupture of membranes	645	25.21%	205	6.46%	30	3.82%
Adverse diagnosis at admission for labour	494	19.30%	253	7.98%	315	40.13%
Pre-term	128	5.00%	243	7.66%	123	15.67%
Post-term	172	6.72%	232	7.31%	5	0.64%
Post-delivery outcomes						
Low-birth weight	180	7.03%	263	8.29%	N/a	N/a
Neonatal death	7	0.27%	23	0.73%	15	1.91%
Postpartum syphilis test positive	50	1.95%	9	0.28%	33	4.20%
Postpartum anemia	279	10.90%	125	3.94%	83	10.57%
Stillbirth	36	1.41%	42	1.32%	33	4.20%
<i>Maternal morbidity index (no.)*</i>	575	22.47%	189	5.96%	238	30.32%

* The maternal morbidity index includes severe UTI, eclampsia, pre-eclampsia and postpartum anaemia, which are all shown in italicised bold in the table. N/a – not available.

Table 16.3: Cost predictions at nominal exchange rates.

Method	Transfer from	Trial arm	Cuba							Thailand							South Africa						
			Lower	Mean	Upper	% of CPP	Overlap	US\$ diff	ANC vis	Lower	Mean	Upper	% of CPP	Overlap	US\$ diff	ANC vis	Lower	Mean	Upper	% of CPP	Overlap	US\$ diff	ANC vis
Observed COST		Control	382	402	422					103	106	109					324	347	370				
		Intervention	347	372	397					83	86	88											
		Difference	-2	30	63			-30.0	-2.5	16	20	24			-19.8	-3.0							
Direct transfer	From Cuba	Control								382	402	422	381%	n	296.4	45.2	382	402	422	116%	n	54.9	7.6
		Intervention								347	372	397	434%	n	286.2	43.6							
		Difference								-2	30	63	151%	y	10.2	1.6							
	From Thai	Control	103	106	109	26%	n	-296.4	-24.5								103	106	109	30%	n	-241.5	-33.4
		Intervention	83	86	88	23%	n	-286.2	-23.6														
		Difference	16	20	24	66%	y	-10.2	-0.8														
	From S AF	Control	324	347	370	86%	n	-54.9	-4.5	337	353	371	335%	n	247.5	37.7							
		Intervention								132	175	217	166%	n	69.5	10.6	361	477	594	137%	y	130.0	18.0
		Difference								115	152	188	177%	n	66.3	10.1							
Unit cost transfer	From Cuba	Control																					
		Intervention																					
		Difference																					
	From Thai	Control	129	166	203	41%	n	-235.9	-19.5								112	142	173	41%	n	-205.0	-28.3
		Intervention	106	136	165	37%	n	-235.9	-19.5														
		Difference		30		100%	y	0.0	0.0														
HSU transfer	From S AF	Control	337	383	433	95%	y	-18.8	-1.6	182	207	234	196%	n	101.7	15.5							
		Intervention								129	166	203	157%	n	60.5	9.2	315	366	418	105%	y	19.0	2.6
		Difference								106	136	165	159%	n	50.3	7.7							
	From Thai	Control	132	175	217	44%	n	-226.9	-18.7								171	199	227	57%	n	-148.0	-20.4
		Intervention	115	152	188	41%	n	-219.9	-18.1														
		Difference		23		77%	y	-7.0	-0.6														
Staff method	From S AF	Control	343	454	564	113%	y	51.6	4.3	103	131	159	124%	y	25.5	3.9							
		Intervention	264	304	347	76%	y	-97.9	-8.1	89	144	198	136%	y	38.5	5.9	337	353	371	102%	y	6.0	0.8
		Difference		17		57%	y	-13.0	-1.1		18		91%	y	-1.9	-0.3							
ICIM		Control	382	402	422	100%	y	0.0	0.0	103	106	109	100%	y	0.0	0.0	324	347	370	100%	y	0.0	0.0
		Intervention	295	321	344	86%	n	-50.9	-4.2	81	89	100	104%	y	3.7	0.6	337	353	371				
		Difference		81		269%	y	50.9	4.2		16		81%	y	-3.8	-0.3	9	-6	-24				
Regression	Own country	Control	78	289	1071	72%	y	-112.6	-9.3	47	99	210	94%	y	-6.5	-1.0	181	271	407	78%	y	-76.0	-10.5
		Intervention	65	216	720	58%	y	-155.9	-12.9	45	69	106	81%	y	-16.7	-2.5	189	275	410				
		Difference		73		244%	y	43.3	3.6		30		151%	n	10.1	1.5		-4					
	From Cuba	Control								65	192	568	182%	y	86.2	13.1	116	400	1376	115%	y	52.9	7.3
		Intervention								60	182	540	212%	y	96.3	14.7							
		Difference									10		49%	y	-10.2	-1.5							
	From Thai	Control	41	156	595	39%	n	-246.0	-20.3								77	148	285	43%	n	-199.0	-27.5
		Intervention	37	150	580	40%	n	-221.9	-18.3														
		Difference		6		20%	y	-24.1	-2.0														
	From S AF	Control	191	268	378	67%	n	-133.7	-11.0	151	193	245	183%	n	87.1	13.3							

Table 16.4: Cost predictions using purchasing power parities.

Method	Transfer from	Trial arm	Cuba							Thailand							South Africa						
			Lower	Mean	Upper	% of CPP	Overlap	US\$ diff	ANC vis	Lower	Mean	Upper	% of CPP	Overlap	US\$ diff	ANC vis	Lower	Mean	Upper	% of CPP	Overlap	US\$ diff	ANC vis
Observed COST		Control	908	957	1005					199	205	211					502	538	574				
		Intervention	826	885	945					162	167	171											
		Difference	-6	71	149			-71.4	-5.9	31	39	46			-38.5	-5.9							
Direct transfer	From Cuba	Control								908	957	1005	4.66	n	751.4	62.0	908	957	1005	1.78	n	418.7	34.5
		Intervention								826	885	945	5.31	n	718.5	59.3							
		Difference								-6	71	149	1.85	y	32.9	2.7							
	From Thai	Control	199	205	211	0.21	n	-751.4	-62.0								199	205	211	0.38	n	-332.8	-27.5
		Intervention	162	167	171	0.19	n	-718.5	-59.3														
		Difference	31	38	46	0.54	y	-33.0	-2.7														
Unit cost transfer	From S AF	Control	502	538	574	0.56	n	-418.7	-34.5	522	547	575	2.67	n	342.1	28.2							
		Intervention								314	417	516	2.03	n	211.4	17.4	859	1135	1414	2.11	n	597.4	49.3
		Difference								274	362	447	2.17	n	195.2	16.1							
	From Thai	Control	251	323	395	0.34	n	-633.8	-52.3								218	276	336	0.51	n	-261.8	-21.6
		Intervention	206	264	321	0.30	n	-620.7	-51.2														
		Difference		58		0.82	y	-13.2	-1.1														
HSU transfer	From S AF	Control	522	594	670	0.62	n	-362.8	-29.9	282	321	363	1.57	n	116.0	9.6							
		Intervention								251	323	395	1.57	y	117.6	9.7	309	353	397	0.66	n	-184.9	-15.3
		Difference								206	264	321	1.59	n	97.8	8.1							
	From Thai	Control	314	417	516	0.44	n	-540.0	-44.6								265	308	352	0.57	n	-229.4	-18.9
		Intervention	274	362	447	0.41	n	-523.4	-43.2														
		Difference		55		0.77	y	-16.7	-1.4														
Staff method	From S AF	Control	532	703	874	0.73	y	-253.5	-20.9	201	255	309	1.24	n	49.6	4.1							
		Intervention	628	724	826	0.76	n	-233.0	-19.2	173	280	385	1.36	y	74.8	6.2	522	547	575	1.02	y	9.3	0.8
		Difference		40		0.57	y	-31.0	-2.6	144	245	346	1.47	y	78.3	6.5							
ICIM		Control	908	957	1005	1.00	n	0.0	0.0	199	205	211	1.00	y	0.0	0.0	502	538	574	1.00	y	0.0	0.0
		Intervention	702	764	819	0.86	y	-121.1	-10.0	157	174	194	1.04	y	7.2	0.6	522	547	575				
		Difference		193		2.69	y	121.1	10.0		31		0.81	n	-7.3	-0.6	9	-9	-24				
Regression	Own country	Control	186	689	2550	0.72	y	-268.0	-22.1	91	192	408	0.94	y	-12.6	-1.0	293	426	636	0.79	y	-111.6	-9.2
		Intervention	155	514	1714	0.58	y	-371.0	-30.6	87	134	206	0.81	y	-32.5	-2.7	280	420	630				
		Difference		174		2.44	n	103.0	8.5		58		1.51	y	19.7	1.6		6					
	From Cuba	Control								154	456	1351	2.22	y	251.2	20.7	277	952	3275	1.77	y	413.9	34.2
		Intervention								143	433	1285	2.60	y	266.6	22.0							
		Difference									23		0.60	y	-15.5	-1.3							
	From Thai	Control	80	303	1157	0.32	y	-653.5	-53.9								149	288	555	0.53	y	-250.1	-20.6
		Intervention	72	292	1128	0.33	y	-593.5	-49.0														
		Difference		11		0.16	y	-60.0	-5.0														
	From S AF	Control	295	416	585	0.43	n	-540.8	-44.6	235	299	380	1.46	n	93.4	7.7							

Table 16.5: Cost prediction using simplified staff costing method in Cuba

	Workers				Salary		Total cost		OPV		Predicted cost			Actual		Ratio	Overlap
	Obstet	Doctor	Nurse	Other	costs	High	Mean	Low		Low	Mean	High	Low	Mean	High		
13 de Marzo	3	48	48	12	31950	75855	68962	62968	7305	8.62	9.44	10.38	11.46	12.27	13.08	1.30	n
Albarran	4	48	48	6	31500	74786	67991	62081	8916	6.96	7.63	8.39	11.06	11.86	12.65	1.55	n
Galvan	2	34	34	6	22200	52707	47917	43752	5151	8.49	9.30	10.23	16.12	18.36	20.60	1.97	n
Manduley	2	52	37	11	30000	71225	64753	59125	11322	5.22	5.72	6.29	8.39	9.13	9.86	1.60	n
Romay	3	42	42	11	28200	66952	60868	55577	10707	5.19	5.68	6.25	9.22	10.01	10.81	1.76	n
Zulueta	3	34	34	85	34500	81909	74466	67994	11662	5.83	6.39	7.02	10.58	11.46	12.34	1.79	n
Abaili	4	48	48	9	31950	75855	68962	62968	7487	8.41	9.21	10.13	11.16	12.31	13.45	1.34	n
Escalona	2	64	64	16	41700	99003	90006	82184	11074	7.42	8.13	8.94	7.77	8.28	8.79	1.02	y
Guiteras	3	15	15	9	11700	27778	25254	23059	3297	6.99	7.66	8.43	12.95	17.85	22.74	2.33	n
Reina	4	48	48	22	33900	80484	73171	66811	12202	5.48	6.00	6.60	11.02	12.15	13.27	2.03	n
Tamayo	2	26	26	9	17850	42379	38528	35179	4940	7.12	7.80	8.58	12.27	13.85	15.44	1.78	n
Vantroi	4	42	42	15	29250	69444	63134	57647	16149	3.57	3.91	4.30	7.71	8.28	8.86	2.12	n
Average	3	42	41	18	28725	68198	62001	56612	9184	5.58	7.24	8.89	8.99	12.15	15.31	1.715404	n
											1.72			3.28			
Obstet		450															
Doctor		350															
Nurse		250															
Worker		150															
% staff	0.54	0.565	0.59														
% direct	0.78	0.82	0.86														
	Workers				Salary		Total cost		IPD or		Predicted cost			Actual		Ratio	Overlap
	Obstet	Doctor	Nurse	Other	costs	High	Mean	Low	cases	Low	Mean	High	Low	Mean	High		
AB	6	0	10	3	5650	13414	12195	11135	290	38.40	42.05	46.26	39.37	51.72	64.07	1.23	n
C	5	0	9	5	5250	12464	11332	10347	848	12.20	13.36	14.70	13.89	16.76	19.63	1.25	y
E	10.5	0	8	2	7025	16679	15163	13845	520	26.63	29.16	32.07	23.95	30.84	37.72	1.06	y
F	3.7	0	7	4	4015	9532	8666	7913	334	23.69	25.95	28.54	29.14	36.75	44.35	1.42	y
LABOUR	1	0	14	6	4850	11515	10468	9559	725	13.18	14.44	15.88	16.45	21.32	26.20	1.48	y
NNICU	11.1	0	38	4	15095	35838	32581	29750	313	95.05	104.09	114.50	88.37	118.09	147.82	1.13	y
OT	7.5	0	24	2	9675	22970	20883	19068	220	86.67	94.92	104.41	70.12	113.98	157.83	1.20	y
Obstet		450															
Doctor		350															
Nurse		250															
Worker		150															
% staff	0.54	0.565	0.59														
% direct	0.78	0.82	0.86														

Table 16.6: Cost prediction using simplified staff costing method in Thailand

Health promotion unit	Workers			Salary	Total costs			OPV	Predict			Actual		Ratio	Overlap	
(hospital)	Doctor	Nurse	Other	costs	High	Mean	Low		Low	Mean	High	Low	Mean	High		
Chumpae	0	4	4	1908	4969	4663	4317	303	5.7	6.2	6.6	5.4	5.7	6.1	0.93	y
Banphai	0	3	2	1240	3229	3030	2805	208	5.4	5.8	6.2	6.1	6.4	6.7	1.10	y
Puwieng	0	3	2	1240	3229	3030	2805	200	5.6	6.1	6.5	4.1	4.6	5.1	0.76	n
Manjakiri	0	2	3	1145	2982	2798	2590	171	6.1	6.5	7.0	6.4	6.8	7.2	1.04	y
Khaosankuang	0	3	4	1622	4224	3964	3670	96	15.3	16.5	17.6	8.5	9.1	9.8	0.55	n
Waengnoi	0	4	0	1144	2979	2796	2588	51	10.1	11.0	11.7	6.1	6.6	7.2	0.61	n
Kranuan	0	3	3	1431	3727	3497	3238	270	4.8	5.2	5.5	7.7	8.4	9.1	1.62	n
Nongsonghong	0	4	1	1335	3477	3262	3020	151	4.0	4.3	4.6	3.4	3.6	3.8	0.84	n
Phon	0	4	0	1144	2979	2796	2588	115	9.0	9.7	10.4	6.2	6.6	6.9	0.67	n
Nongrua	0	5	2	1812	4719	4428	4100	313	5.2	5.7	6.0	4.8	5.0	5.2	0.88	y
Sichompoo	0	4	9	2863	7456	6997	6477	162	8.0	8.6	9.2	4.7	5.2	5.7	0.60	n
Nampong	0	5	5	2385	6211	5828	5396	219	9.9	10.6	11.3	5.3	6.2	7.1	0.58	n
Average	0.0	3.7	2.9	1605.8		3924.1		188.3	6.10	8.02	9.94	5.34	6.19	7.04	0.8	y
Doctor			478								3.47			1.54		
Nurse			286													
Worker			191													
% staff	0.64	0.66	0.68													
% direct	0.6	0.62	0.65													
Inpatient ward	Workers			Salary	Total costs			IPD	Predict			Actual		Ratio	Overlap	
(hospital)	Doctor	Nurse	Other	costs	High	Mean	Low		Low	Mean	High	Low	Mean	High		
Chumpae	1	20	16	9254	18473	17369	16674	5378.0	3.1	3.2	3.4	3.0	3.3	3.73	1.03	y
Banphai	1	27	12	10492	20945	19692	18905	1846.0	10.2	10.7	11.3	6.9	7.4	7.95	0.70	n
Puwieng	2	21	3	7535	15042	14142	13577	1674.0	8.1	8.4	9.0	6.1	6.5	6.87	0.77	n
Manjakiri	1	16	12	7346	14664	13788	13236	1622.0	8.2	8.5	9.0	5.2	5.7	6.18	0.67	n
Khaosankuang	1	13	1	4387	8758	8234	7905	522.0	15.1	15.8	16.8	9.7	10.6	11.51	0.67	n
Waengnoi	1	11	6	4770	9522	8953	8595	864.0	9.9	10.4	11.0	5.7	6.2	6.73	0.60	n
Kranuan	2	31	16	12878	25708	24170	23204	2382.0	9.7	10.1	10.8	8.6	9.2	9.77	0.91	y
Nongsonghong	1	10	6	4484	8951	8416	8079	1180.0	6.8	7.1	7.6	6.0	6.3	6.60	0.88	n
Phon	1	20	18	9636	19236	18086	17362	2249.0	7.7	8.0	8.6	4.9	5.3	5.71	0.66	n
Nongrua	1	18	6	6772	13519	12710	12202	421.0	29.0	30.2	32.1	5.5	6.1	6.62	0.20	n
Sichompoo	1	14	7	5819	11616	10922	10485	1194.0	8.8	9.1	9.7	5.3	5.8	6.27	0.64	n
Nampong	1	19	10	7822	15615	14681	14094	1938.0	7.3	7.6	8.1	5.9	6.3	6.80	0.84	n
Average	1.2	18.3	9.4	7599.6		14263.5		1772.5	7.03	10.77	14.51	5.54	6.56	7.59	0.7	y
Doctor			478								6.77			1.85		0.71
Nurse			286													
Worker			191													
% staff	0.69	0.72	0.74													
% direct	0.726	0.74	0.75													
Labour ward	Workers	Workers		Salary	Total costs			Cases	Predict			Actual		Ratio	Overlap	
(hospital)		Nurse	Other	costs	High	Mean	Low		Low	Mean	High	Low	Mean	High		
Chumpae		2	0	572	4468	4077	3737	157	23.8	26.0	28.5	9.2	9.9	10.6	0.38	n
Banphai		10	7	4197	2904	2650	2429	116	20.9	22.8	25.0	37.5	40.1	42.6	1.75	n
Puwieng		1	2	668	2904	2650	2429	137	17.7	19.3	21.2	21.9	22.8	23.6	1.18	n
Manjakiri		5	1	1621	2681	2447	2242	67	33.5	36.5	40.0	30.0	31.5	33.1	0.86	y
Khaosankuang		2	1	763	3799	3466	3177	24	132.4	144.4	158.3	19.8	21.3	22.7	0.15	n
Waengnoi		1	1	477	2679	2444	2241	14	160.0	174.6	191.4	58.1	65.1	72.1	0.37	n
Kranuan		9	4	3338	3351	3058	2803	240	11.7	12.7	14.0	20.4	20.8	21.2	1.64	n
Nongsonghong		5	1	1621	3126	2853	2615	82	31.9	34.8	38.1	11.6	12.5	13.4	0.36	n
Phon		4	2	1526	2679	2444	2241	62	36.1	39.4	43.2	24.7	26.1	27.5	0.66	n
Nongrua		10	3	3433	4244	3872	3549	72	49.3	53.8	58.9	24.2	29.0	33.8	0.54	n
Sichompoo		4	0	1144	6705	6118	5607	59	95.0	103.7	113.6	23.3	25.0	26.7	0.24	n
Nampong		6	5	2671	5585	5096	4671	96	48.7	53.1	58.2	20.6	23.1	25.5	0.43	n
Average	0.0	4.9	2.3	1835.9		3431.1		93.8	31.08	60.10	89.12	19.33	27.25	35.18	0.7	y
Doctor			478								52.47			14.33		
Nurse			286													
Worker			191													
% staff	0.61	0.65	0.69													
% direct	0.7	0.72	0.74													
Operating theatre	Workers			Salary	Total costs			Cases	Predict			Actual		Ratio	Overlap	
(hospital)	Doctors	Nurse	Other	costs	High	Mean	Low		Low	Mean	High	Low	Mean	High		
Chumpae	0	16	14	7250	9785	8435	7361	110	66.9	76.7	89.0		67.0		0.9	y
Banphai	0	4	1	1335	6359	5482	4784	60	79.7	91.4	106.0		47.3		0.5	n
Puwieng	0	3	1	1049	6359	5482	4784	176	27.2	31.1	36.1		39.0		1.3	n
Kranuan	0	5	2	1812	7338	6326	5521	3026	1.8	2.1	2.4		56.2		26.9	n
Nongsonghong	0	1	1	477	6846	5902	5150	19	271.1	310.6	360.3		185.1		0.6	n
Phon	0	6	2	2098	5867	5057	4414	12	367.8	421.5	488.9		141.6		0.3	n
Nongrua	0	0	0	0	9292	8011	6991	24	297.5	340.9	395.4		53.4		0.2	n
Nampong	0	6	0	1716	12231	10544	9201	622	14.8	17.0	19.7		74.4		4.4	n
Average	0.0	5.1	2.6	1967.1		6904.8		506.1	44.7	161.4	278.1		83.0		2.9	y
Doctor			478								167.93			52.08		
Nurse			286													
Worker			191													
% staff	0.26	0.29	0.32													
% direct	0.75	0.78	0.81													